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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

THE great hydro-electric power station at Alfkarleby, the third of the large Swedish State hydro-electric enterprises, has now been completed and has commenced the distribution of electric energy to a large district where it was much needed. The exploitation of the Alfkarleby Falls on a large scale was first mooted in the year 1893, and within five years plans were prepared, on the basis of a height of fall of 14.5 m. (47 ft. 6 in.) and a volume of water amounting to 150 cub. m. (5297 cub. ft.) per second. Further consideration, however, caused some delay, and it was not till 1910 that the Royal Waterfalls Board, which had in the meantime been constituted, completed the plans, which the following year were passed by the Riksdag, a grant of 510,000*l.* being voted for the purpose. The scheme also included the exploitation of some smaller falls higher up the river in one common power plant. The Söderfors Works claimed some part of the shore and of the power, and, pending certain legal decisions, these works sold the rights in question to the State on the undertanding that they should receive at cost price 15 per cent. of the power, provided their demands did not exceed 4,500 kw. For the provision of appliances for distributing the power a sum of 350,000*l.* has so far been placed at the disposal of the Waterfalls Board.

The Alfkarleby Falls are situated in the Dala River, some 8 km. (5 miles) above its mouth. At the falls the river is divided into three branches (see Fig. 1 on page 30) by two islands named Flakön and Laxön, the three branches being called, from east to west, the Great Fall, the Central Fall and the Kungsadra Fall (King's Fall or "vein"). The two former are steep falls, while the latter is on a flatter gradient. Below the falls proper the river again unites into one stream, which first forms a short but sharp rapid. At low water the height of the Alfkarleby Falls is about 15 m. (49 ft.). The scheme also comprises the falls below the Lanfors Fall, some 4 km. higher up the river, viz., the Nygardsfors, 1.5 m. (4 ft. 11 in.) head, and the Stallfors, 1.75 m. (5 ft. 9 in.) head, the river between the two falls forming the Stallfjärden Pool, of 1.1 sq. km. area (300 acres). By utilising these falls, the available head at the power station is increased to from 16.3 m. to 18.5 m. (53 ft. 6 in. to. 60 ft. 7 in.), as will appear from the table published below, in which heights refer to the mean level of the sea as zero.

Volume of Water. Cub. M. per sec.	Highest Permissible Water Level at Dam. Metres.	Water Level at Turbine Outfall. Metres.	Height of Fall. Metres.
80	20.58	2.15	18.43
100	20.65	2.31	18.34
250	21.00	2.85	18.15
1500	21.80	4.88	16.92
2100	22.50	6.30	16.20

Of the head in question a portion is lost in the inlet canal and in the ice-guards, the available fall at the turbines being reduced by about 40 cm. (16 in.). Below the Alfkarleby Falls lies the Masurfors, about 2 m. (6 ft. 7 in.) high and 800 m. long, in which the Dala River very nearly falls to sea level. This latter fall could not be exploited at Alfkarleby without much expense for dredging. This matter has therefore been allowed to stand over, but the power station has been planned with the possibility in view of also exploiting this fall.

The volume of water in the Dala River varies considerably, and exhibits the features peculiar to North Swedish rivers. The winter is marked by decrease of water, until the melting of the snow sets in, when a violent flood brings about the highest water level of the year. Then the water again begins to fall, at first quickly, but by degrees more slowly until the following spring. There is, however, very often a sudden freshet in the autumn.

In normal years the volume of water at Alfkarleby ranges between 100 and 1,300 cub. m. (3,531 and 45,912 cub. ft.) per second. In dry years it may be as low as 80 cub. m. (2,825 cub. ft.) per second, or less, and in wet years it may rise to above 2,000 cub. m. (70,633 cub. ft.) per second. This latter condition, however, has not occurred since 1860, when the spring flood brought a volume of water amounting to 2,080 cub. m. By regulation of the Dala River, however, the normal low water volume can be raised to about 200 cub. m. (7,063 cub. ft.) per second, and with exceptionally low water to 135 cub. m. (4,767 cub. ft.) per second. As there is the possibility of accumulating water in the Stallfjarden Pool during the night, when the consumption of power generally is less than in the daytime, the station has been built to deal with a volume of water of about 250 cub. m. (8,829 cub. ft.) per second. As a reserve for dry years a steam central station has been built at Västeras.

The situation of the power station in relation to the various dams is shown in Fig. 1. The ground on the eastern shore is fine sand, under which solid rock generally is found at no great depth. At the Great Fall and the Central Fall the rock to a great extent is on the surface, whilst at the King's Fall it is covered with stones, &c. All the structures which have been built have solid rock foundations. The water is raised in level by means of various dams built across the branches of the river above the falls and is led through an inlet canal on the eastern shore to the distribution basin. From thence it flows to open concrete chambers, at the bottom of which the turbines are placed (see Fig. 10, Plate III), passes through the turbines and afterwards flows through suction pipes underneath the machinery hall into the outlet canal in order to join the river below the falls.

In the design of the dams endeavours have been made as far as possible to deliver the overflow water over fixed spillways at the level + 21 m., to which height the water generally is held up. The number and dimensions of the gates and rollers have in this way been minimised, there being only seven outlets with movable parts. The dam in the Great Fall commences close to the intake to the inlet canal with an opening which can be closed with wooden gates. This opening is provided for the purpose of letting through the ice formed immediately in front of the intake. After the ice outlet come two fixed spillways and next four floating openings for the passage of timber, which can be closed with iron gates. The rest of the dam in this branch of the river is made up by six fixed spillways, placed in a curve over the deepest part of the river to Flakön Island. The dam approximately follows the natural neck of the fall. In the Central Fall there are four fixed spillways on each side, and in the middle an opening which can be closed by means of a roller dam. This latter outlet is for the purpose of letting through the ice formed in the river above the fall, especially in the Stallfjärden. In order to direct the ice to the Central Fall a strong timber training jetty runs from the eastern shore across to the southern side of Flakön Island. As the dam has been placed about 150 m. (492 ft.) up-stream above the neck of the fall, it only affects the appearance of the fall very slightly. An earthen embankment has been built round the southern end of Laxön (or Salmon) Island as a protection against flooding. In the King's Fall, or Kungsadra branch, there are included in the dam several salmon ladders to assist the fish in going up-stream (Lax = salmon). Near the salmon ladder there is a small outlet, closed by wooden gates, and then follows a floating opening for timber, which is closed by iron gates. These openings let through the water necessary for allowing the salmon to make their way into the Kungsädra branch to the lower part of the salmon ladder. The rest of the dam is formed by a fixed spillway, which is connected by an earthen embankment to the western shore of the river. With all outlets open the dams, at exceptionally high water level, about + 22.50 m., can let through 2,200 cub. m. water per second, or rather more than the largest volume of water during the exceptional flood of 1860. In the control of the water passing the dam the principle has been adopted that the water shall not rise above the fixed spillways until it exceeds the capacity of the movable outlets. The low water delivery must not be dammed right up to the crown of the fixed spillways, as will appear from the particulars of water levels already given, but a special chart of levels is then followed. In order to increase the capacity of the reservoir and also to be able to follow the indications of the chart without influencing the lower water level of the Lanfors Fall, some dredging has been undertaken in the Nygards Fall.

The spillways and the openings of the dams have a free breadth of 10 m. (32 ft. 9 in.), with the following exceptions: In the curved portion of the Great Dam the six fixed spillways are each 11 m. broad, the roller dam opening in the Central Fall is 20 m. (65 ft. 7 in.) broad, and the fixed spillway in the Kungsadra branch is 60 m. (197 ft.) broad, whilst the opening nearest the salmon ladder in the same branch of the river is 2 m. As already mentioned, the upper edge of the fixed spillways is at level + 21 m., whilst the sills of the various openings are at different levels; thus the sill of the ice outlet of the Great Fall lies at + 19.50, those of the floating openings at + 17.40 (Fig. 4), those of the Central Fall at + 18.30, and the 10 m. opening of the Kungsadra branch at + 18.50 m. The piers between the fixed spillways, of 1.5 m. (5 ft.) breadth, only serve as supports for a roadway of ferro-concrete running along the dams (Fig. 5, Plate II). In addition, the piers at the closing openings and at the roller dam support the operating gear for the movable dams, and are 2.5 m. (6 ft. 7 in.) broad at the gates and 3 m. (9 ft. 10 in.) at the roller dam.

The dams are constructed in mass concrete, with stone facing on the surfaces which are likely to be exposed to the ice. Water-tightness on the up-stream sides has been secured by excavating a groove in the rock (Figs. 4 to 8, Plate II), and filling it with concrete. The body of the dams is formed in mass concrete of a mixture of 1 : 5 : 7, with 20 per cent. of stone plums. Towards the rock bottom and the up-stream side the masonry is covered by a layer 3 cm. thick of concrete of a 1 : 2 mixture, and behind this a further layer of concrete, 15 cm. (6 in.) thick, of a 1 : 2 : 2½ mixture. To avoid contraction cracks a groove was formed at every pier, and the spillway in the Kungsadra branch is also divided by grooves. These grooves are caulked with a double layer of calendrite.

About 0.5 m. (20 in.) behind the up-stream side of the dams there is a drainage system carrying off leakage, consisting of vertical rows of 50-mm. (2-in.) drain pipes, from the surface of the rock up towards the crest of the dam. These pipes are connected to a collecting pipe with its outlet on the down-stream side. To this drainage system other rows of pipes lead from various points of the rock underneath the dam where leakage might make its way. The upper ends of the rows of pipes are connected by means of a nearly horizontal pipe, which is open to the air.

The dam across the Kungsadra branch (Figs. 7 and 8, Plate II) differs somewhat in construction from the others. The rock is here covered with a layer of sand 3 m. to 6 m. (10 ft. to 20 ft.) thick, and as the dam has been carried right down to the rock, the spillway is of a considerable height. So as to reduce the cost, arches have been arranged in the body of the dam, and filled with rubble.

The down-stream edge of the spillways follows fairly closely the natural contour of the ground. In the Central Fall and in the Kungsadra branch (Figs. 5 and 7, Plate II) the dam ends in a slight slope or in small terraces, whilst in the western portion of the Great Fall the edge follows the rock down into the deep clefts on either side of a high rocky ridge, called the Monk. In the Great Fall the spillway on the down-stream side ends in a slope of 1 : 8, as there is plenty of additional fall for the water. The arrangement is different in the Central Fall, inasmuch as the dam is not situated immediately above the fall, the spillways here delivering the water in a horizontal direction. In these cases, the space from the back edge of the dam to the natural rock bottom has been covered with an apron of rough stone set in cement. In the Kungsadra branch, where the bottom below the dam is covered with a thick layer of softer substance, this layer, nearest the dam, is protected by timber cribs (Fig. 8) filled with stone. In addition, the lower portion of the spillway is of such a shape that the water running off is thrown somewhat upwards, as seen in the view, Fig. 2, on page 31.

Near the shore the concrete dams connect up to earthen embankments with a water-tight core. The crests of the earth dams are at + 23.60 m. and the breadth of the crest is about 3 m.; the slopes are pitched with stone at a gradient of 1 : 1.5. The

earth embankment round the southern point of the Salmon Island, with its crest at + 23.25 and of a breadth of 2 m. (6 ft. 7 in.), only rises slightly above the natural level of the ground. Water-tightness is secured by peat caulking between boards on the up-stream side. Earth has been piled over this and then covered with stones, at a slope of 1 : 2.5.

The openings in the dams are closed, as already mentioned, by iron gates (Figs. 3 and 7), by a roller dam (Fig. 6), and by wooden doors. In their closed position the upper edges of the vertical iron gates stand at a level + 21 m., that is, at the same height as the fixed spillways; the level of the roller dam and of the wooden doors is + 21.10 m. The vertical iron doors in the dam of the Great Fall are four in number, 3.6 m. (11 ft. 9 in.) high, with 10 m. (32 ft. 9 in.) free opening, while there is one, 2.5 m. high (8 ft. 2 in.), also with 10 m. free opening in the Kungsadra branch (Fig. 7). The doors at the Great Fall are fitted with a roller at the top and a bogie with two rollers at the bottom. On the door of the Kungsadra branch dam there are two rollers, top and bottom, running on cast-iron rails in the grooves of the dam piers. In addition there are guiding rollers and rails, to prevent the doors from moving sideways. Tightness is secured by means of an oak facing under each door, and by the door being pressed against an accurately hewn stone sill. There are also oak packings, fastened up-stream to the door by metal springs and running in grooves in the pillars, these grooves gradually becoming narrower towards the bottom. Over each door is an iron bridge carried by the piers of the dam, and furnished with a winch, which can be worked either by hand or electrically.

The roller dam in the Central Fall (Fig. 6, Plate II.) closes an opening, 20 m. (65 ft. 7 in.) broad and 2.8 m. (9 ft. 2 in.) high. It consists of a steel cylinder, 21.62 m. long and 2.1 m. (6 ft. 10 in.) in diameter, fitted with a flat shield with an oak lip which, when the dam is closed lies against the accurately hewn edge of the opening. The roller is divided by means of bulkheads into three chambers, of which the central one occupies the greater part of the length. The end chambers are intended for the reception of stoves, should it be found necessary to heat the grooves for the working of the dam in winter. To prevent the roller dam from being raised by high water below it all the chambers are fitted with doors on the down-stream side, through which water can flow into the interior. On the eastern pier is a winch, which can be worked either by hand or by electricity. The roller dam is operated by a heavy wire rope, and is rolled up toothed racks at each end. To prevent accident, should the teeth fail, the dam is held in the western groove by a chain.

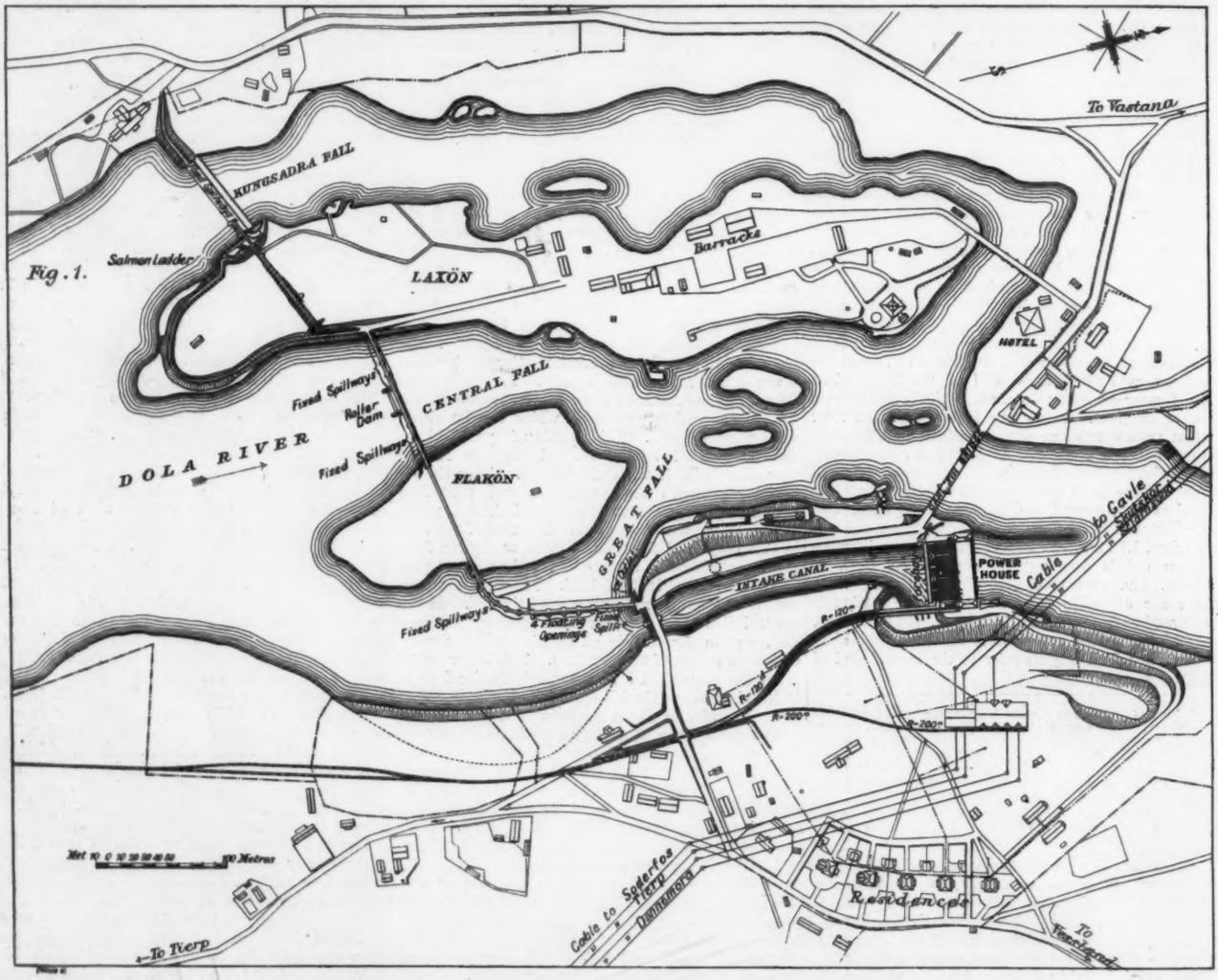
The ice outlet (see Fig. 1) near the canal intake, in the dam of the Great Fall, is closed by means of wooden doors, as is a smaller outlet in the Kungsadra branch (Fig. 12, Plate IV.). The breadth of the ice outlet is 10 m., and its sill is at + 19.50 m. The opening is closed by means of ten wooden doors, which are operated by two hand winches.

The intake canal lies on the highest ridge of rock on the eastern shore of the river, and extends from the dam of the Great Fall down to the power station. The sides of the canal are formed of walls resting upon the rock, and the intake can be closed by iron gates (Fig. 3, Plate II.). At the end nearest the power station the canal expands into a broad basin for the distribution of the water to the different turbine chambers. On the east side the distribution basin is closed by a ferro-concrete wall, with openings temporarily closed, but intended to let the water through to an additional turbine chamber, should an extension of the power station be found expedient. The water intake of the inlet canal comprises two 12.8-m. (42-ft.) openings, with a sill at a height + 12.20 m. (Fig. 3, Plate II.), divided by an intermediate pier, 4 m. (13 ft.) broad.

The doors are generally kept hoisted, and to avoid them projecting too high they are divided in halves. The upper halves, when being hoisted, are guided into a slanting position up-streamwards, when the lower halves can be hoisted up vertically and then tilted. Each half door comprises four horizontal main beams, between which there are vertical secondary beams. On the lower half door the cover-plates, in the usual manner, are laid on the up-stream side, whilst on the upper half they are on the down-stream side. In addition there are guiding rails in the grooves of the piers and land piers, which cause the upper half to assume its proper position. The water pressure is transmitted by means of rollers on the Stoney system to roller rails placed in the grooves of the doors. The doors are hung by chains from steel bridges above and can be operated both by hand and by electricity.

The canal has a breadth at bottom of 16 m. (52 ft. 6 in.) and a depth of about 12 m. (39 ft.) below ordinary water level, and the speed of the water should be about 1.10 m. (3 ft. 9 in.) per

Fig. 1.



second. The canal walls reach to + 24 and are constructed with a batter of 7.5 : 1.

The distribution basin has its bottom at about + 9 m. The western canal wall is continued in a straight line to the power station, the latter portion, however, having a vertical front side instead of being battered. Against the power station this wall ends in an ice outlet 2 m. broad, with its sill at + 18.25 m. (Fig. 10, Plate III), and a bottom outlet of about 0.5 sq. m. opening, which leads through a tunnel in the rock into the river. The ice outlet is closed by means of beams, whilst the bottom outlet is closed by a cast-iron door, which is operated by hand by means of screw gear. On the bottom of the distribution basin, parallel to the power station, runs a groove cut in the rock and ending in the bottom outlet (Fig. 10, Plate III). The eastern wall of the distribution basin turns in a curve until it is almost parallel with the power station and distant from it about 15 m. (49 ft.) (see Fig. 1, page 30). The interval which is formed here is closed with a ferro-concrete screen, as already explained.

In both walls of the distribution basin iron pipes have been inserted, intended to serve as

FIG. 2. THE GREAT FALL SEEN FROM FLAKÖN.

outlets for eels. They proceed from the above-mentioned groove in the bottom of the distribution basin to wells located in the wall. By special arrangements a current of water from the distribution basin is created in these pipes, whereby the eels are sucked up into the wells, from whence they are sent into wooden trunks, leading down to the water level of the river. The eastern trunk is built in connection with a salmon ladder for downward-bound salmon, beginning in an opening in the wall in the distribution basin, proceeding east of the power station, and ending in the outlet canal.

The turbine chambers (see Figs. 9 and 10, Plate III) are five in number and are of ferro-concrete ; the water flows in from the distribution basin through openings of about 65 sq. m. (700 sq. ft.) area each, closed by iron doors. Above the level of + 9 m. the chambers are divided into three groups of respectively 1, 2 and 2 chambers. The crowns of the chambers are at the level + 24 m. and their bottoms at the level + 4.30 m. The concrete walls are thus almost 20 m. (65 ft. 7 in.) high. The distance from centre to centre of the turbines is 10 m. The thickness of the intermediate walls above the level + 20 m. is 1 m., between this height and the level + 9 m. the thickness of each wall of the pairs dividing the groups is 1.5 m., and of the single walls 2 m. Below the level + 9 m. all the intermediate walls are 3.6 m. (11 ft. 9 in.) thick. The breadth available for the water in the chambers is thus in the upper portion 8.5 m. (27 ft. 11 in.), in the next part 7.5 m. (24 ft. 8 in.), and in the lowest portion, beneath level + 9 m., 6.4 m. (21 ft.). The water flows into the chambers over concrete sills at a height of + 9 m., and the length of the chambers inside these sills is about 16 m. (52 ft.). Their total constructive length is close upon 30 m. The partition walls between the chambers are let into the bottom of the chambers ; in addition they are mutually connected by two strong reinforced-concrete beams, 1.5 m. high, with their lower edges at level + 18 m., and by a screen of reinforced concrete, which also serves as a closing partition against the distribution basin above the level + 18 m. (Fig. 10). The walls are doubly reinforced vertically from a level — 0.7 m. to the upper edge. The walls towards the machinery hall are constructed as reversed arches and are strongly reinforced, in the upper part with steel bar, and in the lower with plate. The thickness of each arch above the level of + 20 m. is 0.3 m. (12 in.), and between this level and level + 9.25 m. 0.6 m. (2 ft.). Below this latter height the arch is incorporated with the up-stream wall of the machinery hall. The dimensions of the turbine chambers will be realised from the fact that the quantity of concrete used for the walls amounts to about 9,500 cub. m., and the iron used for reinforcing to about 800 tons.

The walls and bottom surfaces of the chambers are finished with a layer of cement, 4 cm. (1.2 in.) thick nearest the bottom, and 3 cm. thick higher up. To prevent cracking of the surface, wire netting was inserted in the cement plaster and attached to wires in the concrete. To make this layer as tight as possible, ceresite was added to the last layer but one of cement, put on during the plastering.

The turbine chambers can be closed by means of doors made of beams and strengthened with iron girders, in addition to the iron gates already described. These doors (Fig. 10, Plate III, and Figs. 13 and 14, Plate IV) are divided into two, horizontally, each half being constructed with three horizontal main girders, between which are vertical beams. The covering is of buckle plates. Each half gate, with four roller carriages, two on each side, rests against rails in iron grooves. The halving of the gates has, amongst other advantages, that the pressure distribution on the different rollers can be exactly calculated. The gates are coupled together and are thus both hoisted simultaneously. When the closed gates have to be opened, the upper one is raised slightly by means of hand-operated jack-screws. The lower half then follows, water being let in through the interval between the upper and the lower gates. The turbine chamber can also be filled through two hand-operated valves (Fig. 13) placed in the covering of the upper gate. It is not until the water level in the turbine chamber has risen to about the same level as that of the distribution basin that the gates are raised by winches, which can be worked both by hand and by electricity. Water-tightness is secured by oak packings. For protection against weather and wind the gates are sheltered by a wooden structure (Fig. 10). In ordinary cases the gates need not be raised any higher than is necessary to allow of the water opening being quite free ; but for the purpose of repairs they can be raised so that the bottom edges are about level with the crown of the concrete walls, and in that case they project through the roof of the wooden structure, which for this purpose can be opened. Behind the grooves for the gates there are steam pipes let into the wall, so as to prevent the gates from freezing fast.

Inside the gates the ice-guards are placed. They are supported by the sill underneath the gates and by a strong iron trestle. The ice-guards are made from 18 by 50 mm. (0.7 by 2 in.) rolled iron, with rounded edges, joined in sets of seven each ; they are divided horizontally into halves ; the free distance between the bars is 20 mm. (0.8 in.). The ice-guards are designed to be heated electrically and are insulated from their supports by means of oak blocks. The necessary transformers for the heating of the ice-guards are placed in an addition to the wooden structure over the gates.

The turbine chambers are covered with a plank roofing, resting on iron girders. In the bottom of the turbine chambers there are emptying valves (Fig. 10) operated from the roof. Outside the eastern walls, on a level with the crown of the turbine chambers, there is a branch line to the Upsala–Gäfle Railway (Fig. 1) ; over the turbine chambers and the railway line there are rails for a travelling crane. The goods for the machinery hall are lowered through a shaft between the railway line and the eastern wall of the turbine chamber. From this shaft rails run into the generator hall. The crane in question has a span of 16.5 m. (54 ft. 2 in.) and has two hoisting gears of respectively 10 and 50 tons capacity.

The machinery hall of the power station is 13.7 m. (45 ft.) broad, 13.55 m. (44 ft. 6 in.) in height, and 61.87 m. (203 ft.) long. The distance between the units, as already mentioned, is 10 m. The floor is at the level + 5.50 m. and thus 0.7 m. below the exceptional high-water level in the outlet, which reaches a height of + 6.20 m. Below the floor are, further, the pits for the generators, a cable conduit, and some of the controlling appliances for the turbines. Special precautions had to be taken to keep out the water. The foundation of the generator hall consists of a reinforced-concrete base above the suction pipes. Above this and along the vertical walls damp-proof asphalt slabs have been laid, and on the inside of the vertical walls reinforced concrete has been laid, strong enough to resist any possible water pressure that might arise. In the concrete above and inside the damp-proof courses there is a drainage system, which terminates in a sump at the western end of the wall. On the up-stream side the asphalt course is traversed by warm-air channels from the generators. These are drained to a pipe which also ends in the above-mentioned sump. The floor is covered with Metlach tiles.

The outer walls of the machinery house are built of brick, hard hand-made bricks being used for the outside. On the inside the walls are covered with glazed tiles in their lower part and plastered above. The roof is supported by iron brackets and consists of an inner roof of reinforced concrete and an outer roof of tiles on wood. At both ends of the building the cold-air intakes project above the roof ; they are wooden structures with iron trellis openings. The greater number of these openings are in the eastern tower, and from there the air is conveyed between the inner and the outer roof to the western end of the building, where it mixes with the air flowing in there and proceeds through a vertical trunk of scagliola down to the cable conduit below the floor of the machinery hall. The outer roof and the cold-air intake are covered on the inside with plate iron as a protection against fire. From the warm-air channels between the turbine chambers and the up-stream wall of the machinery hall, flues lead partly to the

machinery hall for the sake of heating it, and partly to the interval between the outer and the inner roof to temper the cold air. The superfluous warm air passes out through wooden outlets with iron trellis, placed above the warm-air channels in the turbine pools, but when required it can be led into the turbine chambers to prevent the formation of ice there.

In the machinery hall a 66-ton travelling crane of 13.2 m. (43 ft. 4 in.) span is installed. The machinery hall contains the regulating appliances for the turbines, the generators, which will be dealt with in a subsequent article, and pump and ejector for emptying the sump, to which reference has been made above. The ejector receives its driving water from the distribution basin. From the eastern end of the machinery hall a spiral staircase leads down to the cable conduit. At the western end of the hall there are two galleries, one for instruments and the other for visitors.

The level of the water below the outlet canal varies from + 6.20 m. with exceptional high water to + 2.15 m. at low water. When the Masur Fall is dredged, the low water level will be lowered to about + 0.65 m., whilst the higher water level will be only slightly affected. The outlet canal has been designed with a view to such dredging. It is about 50 m. broad and its bottom rises from about height — 6.50 m. nearest at the machinery house to about height — 3.0 m. at the outlet into the river. Along the western side of the canal a training wall proceeds from the machinery house, about half the length of the canal. Its purpose is partly to prevent the canal from becoming shallow from mud carried along by the river, partly to lower the water level in the canal. So far this wall has only been carried just above mean water level; but should, at high water, too much mud be swilled into the outlet canal, the top of the wall can be raised.

(To be continued.)

ROADS AND PAVING.

ROAD-MAKING with all that facilitates transport, whether of goods or passengers, contains problems that interest the engineers of all nations, and consequently the need for International Road Congresses has made itself felt. The last was held in London in 1913, at which many urgent questions were discussed, and the deliberate decisions of the many experts present will be received with due attention by all who are interested in the maintenance of highways. From these decisions may be inferred the defects in present construction, and the methods that suggest themselves as practical remedies. There is, however, another source of information, namely, that to be drawn from the examination of roads that have been submitted to different amounts and character of traffic, for every roadway may be regarded as an experiment in paving and paving construction. Moreover, it is an experiment from which conclusions can be drawn only after a considerable lapse of time and the due consideration of many variables that are not found collected within a small area. The varying gradients of the streets, the amount of rainfall in the district, the range of temperature, easy access to suitable materials and many other factors have to be taken into account before the permanent efficiency of a particular method can be established. A comparison of the results attained therefore under different circumstances and also under different methods of administration is a valuable guide in indicating correct procedure under new conditions, and such an assistance has been provided by Mr. H. W. Durham, the Highway Engineer of the Borough of Manhattan (N.Y.) and a delegate to the London Congress, who has embodied the results of his observations made during a visit to many of the principal towns of Great Britain and Europe in a report,* now before us. This report, though intended in the first place to substitute accurate information concerning the pavement maintenance conditions in the most advanced municipalities of the world "in place of the vague generalities and unintelligent criticisms frequently used about New York pavements," may well serve a wider end and appeal to a larger public.

There is ample evidence that Mr. Durham has suffered at the hands of amateur critics, and his experience will have been shared by many other road engineers. The many variables in the general problem to which we have alluded are very insufficiently weighed by an impatient public, who consider only their own convenience and find repairs as annoying as the evils they are intended to remove. The passenger who finds a thoroughfare obstructed recalls with a sense of injury the smooth, resilient roadways over which he has driven in some other town and condemns the local authorities as very inefficient, since they have not provided equally luxurious travelling. He is apt to forget that his attention was confined during his chance visit to the best residential streets and the most ornamental quarters of the town, and that a more intimate acquaintance with all the circumstances is necessary before he is in a position to recommend some particular practice to the notice of the road engineer, who soon wearies of uninstructed criticism.

Mr. Durham, we may be sure, does not fall into the error of comparing the maximum results, on which generous expenditure has been lavished, with the average conditions, or with those in which unusual difficulties have had to be overcome. His examination has been as thorough as time permitted of all that is typical of the best paving practice in European cities, noting the points, if any, of superiority in the methods and results over American work. Mr. Durham hopes that his true picture of the conditions that obtain in European streets and the deductions that he has drawn will prove "an answer to unjust and assist helpful criticism." We trust he will not be disappointed, but in any case such a comparative review is as interesting as it is occasionally necessary, if we would forsake the well-worn grooves of easy repetition and meet the changes that constant improvement in vehicular traffic necessitates. It should be, moreover, a salutary and profitable lesson to see ourselves as others see us. We can too readily tolerate that to which we are long accustomed, and we require the knowledge of what other nations are effecting, and what standard of excellence they have adopted, to spur us on to greater efforts, or, it may be, to teach us the necessity of submitting to inevitable evils. Mr. Durham's report is informing rather than critical. He sets down what he has seen, emphasizes his observations by many typical photographs, and invites us to draw our own inferences. He submitted to be led about by high-placed officials and cordially admired the best side of their work, but breaking away from this kindly supervision, he traversed many miles of streets in the towns visited, noting not only the good points, but the inferior conditions prevalent, storing up evidence of the ordinary methods of doing constructive, maintenance, and repair work, when not under formal inspection.

The survey was limited to Great Britain and the countries of Central Europe where the conditions of climate and of traffic resembled those obtaining in New York. Russia, the Scandinavian countries, Spain and Southern Italy were excluded by reasons of climate, and, further, critical examination was restricted to large towns, sea ports, business and manufacturing centres, since only in such places would the traffic conditions of New York be approximately repeated. As a consequence, nothing is said of that network of country roads, with which we are familiar, connecting village with village, roads that in the aggregate carry much traffic and maintain a very fair surface, not being rendered uneven by motors or severely broken into holes. Had Mr. Durham's comprehensive survey included comparison between these less-used roads and those fulfilling a similar purpose in the States, we think so impartial a critic would have given a verdict in our favour. We enjoy not only the advantage of an older construction, but the comparative excellence of such country roads depends greatly on the evenness of the distribution of population. Small scattered communities usually dispense with a well-consolidated road crust, for they cannot afford to maintain such long and little-used roads in efficient repair. Of metropolitan roads, Mr. Durham leaves the general impression that Manhattan has nothing to learn from London or from Europe, and that it is only rare and occasional pieces of road construction that can compare with the best work of New York. America no doubt has profited by the abundant supply of bituminous binding materials, obtained from natural deposits and from petroleum distillation, which were employed in American road-making while we were still experimenting with mud-binding, and had not recognized the contradiction implied in the term "water-bound roads." It is now admitted in this country that some kind of pitch or bituminous material is required to bind the stones in the road crust, so as to ensure a real cohesion and one resisting entrance to water. The cost of construction is increased by the use of such materials, and will not grow less in face of the severe competition for the possession of tars and refuse from our gas works.

The author also is silent on another point of great practical importance. He refers necessarily to light and heavy traffic, but he does not discuss or insist upon the change that has overtaken vehicular traffic, involving as it does a study of the action of the wheel on the roads according to the varying type of vehicles running, a feature of such importance as to displace in some measure the consideration of good foothold for horses. Motors and mechanical transport demand a hard road which will not be slippery, but horse-drawn and mechanically-propelled vehicles are likely for many years to travel on the same surface, and it is difficult to accommodate the claims of each. The problem for the engineer is not made any simpler by the frequent necessity for providing tram lines through the centre of the street, with insistence on the maintenance of a practical continuity of surface with close and permanent contact between the road and rail under all conditions of use and temperature.

The comparison between the road construction that prevails in many countries discloses the striking similarity that pervades the practice in general. The choice of materials is limited, and the methods of formation permit little variety. Administration, too, varies more in name than in intention, the control being usually vested in the direction of a municipal elective body, and only minute differences are noticeable in the distribution of responsibility. The administration in this country is of a very motley character, notwithstanding that much has been done of late to simplify the mechanism of our highway boards and trusts. It would pass the wit of man to explain the operation of the many authorities and the differences of administration that characterize the control of the road between London and Holyhead, or any similar length of highway. In the French system a more homogeneous organization exists, dispensing with that regard for vested interests and historic precedent so reverenced by the British public. It may therefore be a matter of congratulation that an unprejudiced critic is able to record that, "judging from the results, the illogical arrangements prevalent in Great Britain are more efficient than the simpler arrangements pursued in France." Germany, who regards scientific organization as the one thing needful, exercises through its central government powerful control over all street arrangements, settling many trifles that in less paternally governed countries are left to the will of the individual, and securing by the omnipotent whip of authority "a very uniform standard condition of streets throughout each municipality, and regulating matters down to such details as the proper colour of flowers to achieve uniform effect in window boxes."

Whatever may be the constitution of the governing body that controls the management, the practice of contracting for the necessary work with private firms is nearly universal, but even here the severe discipline in which the German State holds its subjects enables that country to score another triumph. The justice of long guarantee contracts for the maintenance of pavements has been much criticized in less officially dragooned countries, but Berlin not only insists on practically a perpetual guarantee, but justifies her practice and recommends her tactics as worthy of imitation. Admiring citizens, who always praise the action of State

* Street Paving and Maintenance in European Cities. A Report by Henry Welles Durham, Chief Engineer of the Bureau of Highways, City of New York, Office of the President, Borough of Manhattan. 1913.

officials applaud, and perhaps rightly, but whether the contracting firms are as well pleased with the arrangement may be doubted. All the burdens seem to be heavily weighted against the contractor. After construction, he has to maintain the pavement in good condition for four years free of charge, and for the next fifteen years at the annual rate of 5d. per square yard. After the lapse of nineteen years, the price is increased to 6d. per square yard per annum. Finally the rate of maintenance from the thirtieth to the fortieth year is increased to 7d. per square yard. Since the contractor has to maintain not only the asphaltic carpeting, but also the concrete bed, the agreement can be indefinitely prolonged. Should in the course of years the condition of the concrete be deteriorated to such an extent that its renewal is necessary, the contractor must restore the foundation just as he does the asphaltic covering. The German engineer who supplies this information must be a humorist, for he adds, "the great advantage of the whole system lies in the fact that the contractor can never free himself from the agreement . . . on his part he has the certainty of work at fixed prices." We hear nothing of a strike clause, or of any arrangement to meet a rise in wages in forty years or more. Whatever we may think of the equity of the terms imposed, the engineer is able to point to the good condition of the asphaltic streets in proof of the success of the method. Mr. Durham, however, speaks in terms of qualified praise of the Berlin streets. "While those in the main city are in fair order, but not noticeably good condition, in many cases poor maintenance can be observed, quality seeming to vary inversely with the amount of traffic." In the newer Berlin and the parts now under construction, however, the streets leave little to be desired, and here may be "found probably the best appearing compressed rock asphalt pavements in existence." But while maintenance work is not everywhere carried out promptly, of the cleanliness Mr. Durham speaks in high praise. The famous "Unter den Linden" (a broad avenue, a mile long, nearly 200 ft. in width, having wide footways, two driveways, and a central parkway) is cleaned with a thoroughness unequalled elsewhere, electric combined sprinklers and squeegee machines are constantly in use, leaving a surface as absolutely clean as is possible on a street pavement. This fine street, continued by a succession of avenues through the main city park, past Charlottenburg to Grundwald, forming for several miles one of the finest roads in the world, elicits and deserves the author's warm admiration.

Berlin, it must be remembered, enjoys the good fortune of being the youngest born of all the capitals of Europe, so completely do the additions of the last forty years outweigh and overshadow the ancient nucleus that gave them birth. The mileage of new streets added may not be greater than that by which London has been increased within the same time, but in proportion to the older portions the difference is far more marked in Berlin than in London. Of all that has been learned of town planning, Berlin has availed herself, all that makes for facility of transport or increases the amenities has been incorporated into the design. The streets are scientifically laid out, all necessary sub-surface structures are inserted previously to paving, and the streets are absolutely completed in advance of building operations. The preparatory work being effected in logical sequence, little or no subsequent disturbance of the surface is necessary. Mr. Durham, to whom street openings are evidently anathema, is loud in his praise of the thoroughness of German methods. He is evidently impressed with the possibilities of the German metropolis of the future, and he foresees, as all must, that by the addition and consolidation of the suburbs of Charlottenburg, Wilmersdorf, &c., the city proper will provide a worthy habitation of the centre of the German Empire, even though its destiny equals its ambitions.

What has London with its ancient traditions and hampered by its hoary growth to compare with this new birth and heir to the experience of all the ages? How does our overgrown metropolis, with its possibilities limited by the extent of its past services, impress the trained expert skilled in the newest devices of road construction and town planning? We may tolerate from historic association and long custom the inconvenience and shackles that are at once the evidence and the burden of past greatness; but how will the modern engineer, fresh from the creations that unlimited resources and lofty ambitions have executed, view our puny efforts to adopt the ill-fitting growth of an unlovely past to the exacting requirements of the present, and the ever increasing demands of the future? Mr. Durham's verdict is precise and inevitable. London, he tells us, "has never been laid out on any plan, and includes the most unsystematic and complicated aggregation of streets in existence. No one street has any fixed continuous direction or even uniform width." A consequence of this irregular, or lack of, plan is that the streets of London "have to carry the heaviest and most complicated traffic in the world, rendering proper pavements of more importance but of more difficulty to construct than in any other place."

Apparently we have nothing that will compare with the Kaiserdamm Boulevard and the Doberitzer Heer Strasse. We may think that our Thames Embankment possesses some good features, that we have there solved the problem of making a road whose surface remains uninjured under excessive traffic, which is neither dusty in dry weather nor exuding mud in wet, where transport is easy both for passengers and goods, and where the rain water dries off quickly. But our critic is not impressed by the result, though he directs attention to the number of experiments of which that avenue has been the scene in the last ten years. With the exception of one or two prominent intersections —Oxford Street and Tottenham Court Road are thought worthy of notice in this connection—no granite-paved streets are equal to the best in Manhattan. The "water-bound macadam" streets are considered fairly satisfactory for the middle class and poorer districts. In point of cleanliness, however, we score over New York, and it is admitted that our minor thoroughfares and side streets receive equal attention with the more frequented. The control of the traffic by the nod of the omnipotent and unruffled policeman meets with due acknowledgment.

Paris the author appears to have visited at an inconvenient hour, when she did not appear at her best. The streets were in a chaotic condition, passing from the old order of traffic to the new, but its possibilities were regarded more favourably than those of London. The reconstruction of the main lines of thoroughfare under the third Napoleon gave to the city a better organized plan than is to be found in the great towns of Europe, producing a system of radial and circulating avenues. The general plan of traffic communication is comparable with that of Washington, while the provision of a series of boulevards occupying the site of the old city walls adds a character of unique interest. The street traffic and pavement problems are fairly comparable to those of New York, and the same may be said of the number of the disturbances of the street surfaces on account of excavations, tunnels, &c., creating the appearance of a general upheaval. Large areas at present unsatisfactorily paved with macadam, stone, and wood were being repaved with new asphalt, giving an unfinished appearance to the streets. These renewals are carried out under the Public Works Department, a highly centralized organization, more efficient than the scattered and independent control with which we are familiar in Greater London, and at the same time admitting of no opening for lack of co-operation or for friction between various civic authorities, of which examples may be found in the United States. That the organization is efficient and working smoothly is shown by the long-time contracts into which it enters and the apparently equitable terms arranged with the contracting firms. We have already referred to the character of the contracts concluded in Germany, and the contrast with the French methods is striking. The author considers the form of specification agreed upon between the contracting parties so exemplary and valuable that he has given it in full in the Appendix. It is more worthy of imitation than the masterful methods evolved by German autocracy.

Paris it is admitted has held leading rank as a city of fine pavements. The advent of motor traffic has brought in a different and higher standard. Before the war, Paris had recognized the necessity of reconstructing the surface of the streets with material more suitable to present requirements, and was prepared to spend large sums to regain the former position of pre-eminence. The *débacle* of the war has necessarily interfered with the programme.

The same overwhelming disaster makes it difficult to write of or to recall the pleasant granite-paved streets of Brussels, ringing as they are under the iron heel of her wanton despoilers. But it is mainly in the old city that the narrow irregular streets are largely paved with the square stone blocks known as Belgian. Asphalt is or was to be found in the main business quarter and the streets adjacent. A feature from a technical point of view is the thinness of the concrete bed, on the average about 4 in.; but owing to the light traffic the foundation seems to be ample, the pavements on the whole presenting a uniform surface.

Vienna has enjoyed the advantage of being judged by the fine appearance presented by the semi-circular line of boulevards known as the Ringstrasse, diverting attention from the narrow and less carefully maintained streets contained within the site of the older fortifications. The Ringstrasse has a total width of 187 ft., allowing for the construction of "two-service roadways, two parkways and a central driveway, in addition to side walks." The terms are American and we may not translate them accurately, but they conjure up a pleasant picture, furnishing the road engineer with ample opportunity for the display of his science. The pavement in this favoured district is asphalt, but the great majority of the streets of Vienna are paved with large granite blocks, from 8 in. to 10 in. on a side, laid in diagonal courses on sand or gravel foundation. The tendency to replace the granite blocks by a pavement of rock asphalt or of wood is growing. Where the pavement is of soft wood, signs of decay are noticeable, but on the whole a fairly good condition is maintained. The stone-paved streets have an irregular surface, and since the stones rest on no stable foundation and are unprovided with solid joints, they are liable to settlement, while the streets can become very dusty. Many of the side walks, says Mr. Durham, are constructed of large paving blocks, and are as rough as the roadways. But Vienna has felt the necessity of putting her house in order, and before the war was preparing to replace the stone-block paving with some type of asphalt.

It is naturally to the capitals that we look for specimens of the best workmanship and for evidence of enterprise in maintaining the appearance of the streets, but it is equally instructive to examine and contrast the manner in which the problem is treated in towns of less importance, and especially to compare the methods and results in places where the industries and the character of the traffic are similar. Thus among sea ports at home, Liverpool and Glasgow can be compared with Hamburg, Antwerp and Bordeaux abroad; among manufacturing centres Birmingham and Newcastle with Lille, Cologne or Dusseldorf. Ancient cities in whose streets the hum of traffic is subdued, like Oxford, Chester or Edinburgh, can be matched with The Hague, Lucerne and Nancy. At the same time we get glimpses of civic government and of the varieties of executive responsible for local administration.

(To be continued.)

THE ITALIAN STEAMER "MILAZZO."—We read in the *Rivista Marittima* that steamer No. 109, the Milazzo, was launched on May 14 at the Muggiano yard of the Fiat San Giorgio Company. She is being built for the Navigazione Generale Italiana, mainly for the transport of coal. The principal dimensions are the following:—

Extreme length	156 m. = 512 ft.
Length between perpendiculars	150 m. = 492 ft.
Breadth	20 m. = 65 ft. 7 in.
Depth of hold	10 m. = 32 ft. 10 in.
Deadweight carrying capacity	14,200 tons.

The vessel carries 20 Nevada transhipment apparatus, which enable her to be loaded and unloaded in the course of about two days. She can carry also 4,500 tons of oil fuel in her double bottom. The engines are quadruple expansion, of 3,000 horse-power. A sister ship, the Volturno, is now on the stocks.

THE SYKES GEAR-CUTTER FOR DOUBLE HELICAL TEETH.

CONSTRUCTED BY THE POWER PLANT COMPANY, ENGINEERS, WEST DRAYTON.

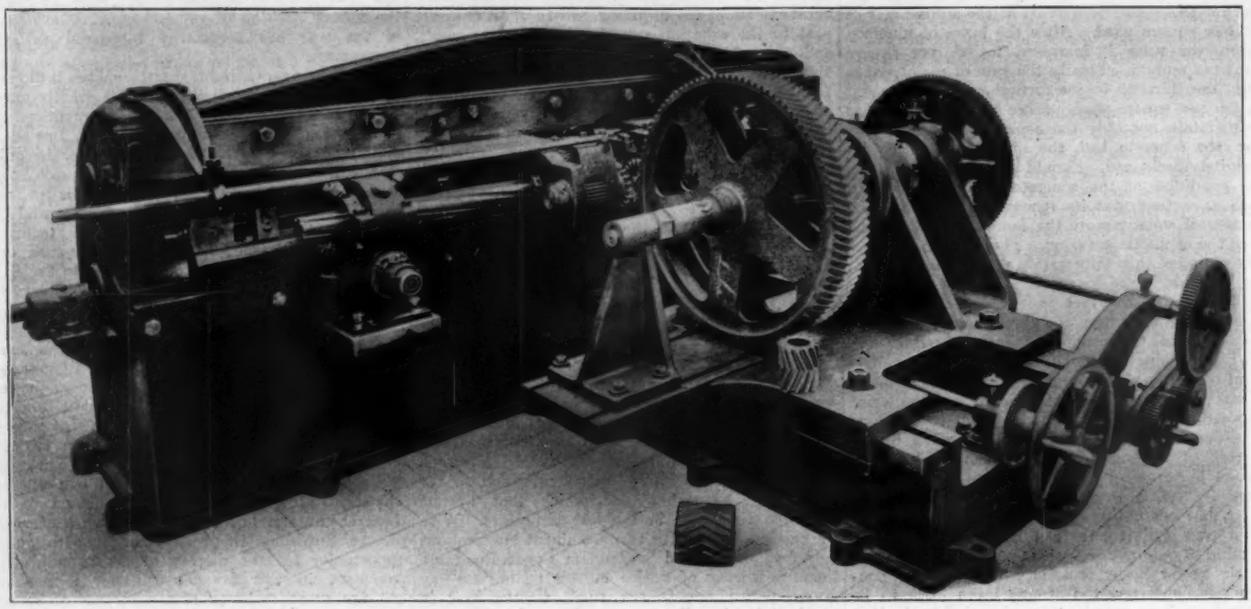


FIG. 1.

ON the present and opposite pages we illustrate a remarkable machine for cutting double helical teeth, designed and patented by Mr. W. F. Sykes, and constructed and used by the Power Plant Company, of West Drayton, Middlesex. The machine is a development of the principle underlying the now well-known Fellowes gear-shaper.

The teeth are formed in the blank by cutters which are themselves gear wheels. The blank and cutter are caused to roll together with the velocity ratio appropriate to the number of teeth on each. At each successive revolution of the blank the latter is fed in towards the cutter, this being continued until the full depth is obtained. The teeth of the blank are therefore "generated," but as compared with hobbing machines, which also generate the teeth cut, it is claimed that a much higher degree of accuracy is attainable in the cutters used than is commercially practicable in the case of hobs. The teeth of the cutters, after forming and hardening, are ground to perfect truth in an automatic machine, which we hope to describe and illustrate at a later date.

Referring to our illustrations, a front view of the machine is represented in Fig. 1, whilst Fig. 2 shows the back. In the foreground of Fig. 1 is shown a wheel cut in the machine, and it will be noticed that the teeth resemble cast double helical gearing in meeting in a sharp angle without the clearance between the two sets of teeth which is necessary in the case of hobbed gears. Two cutters are employed, one of which cuts the teeth belonging to the left-hand helix, and the other those corresponding to the right-hand helix. The cutters are reciprocated to and fro by cranks, and can therefore be caused to cut "to a line." It is this feature which makes it possible to abolish the clearance between the two sets of teeth. As the cutters reciprocate they are twisted by the action of rifle-bars, this giving the helical motion required. At each cut both cutter and blank are turned together through a small angle by means of a ratchet mechanism, so that the two roll together with the relative velocity appropriate to the number of teeth on each. The action is very rapid, the work being finished in about half the time necessary with hobbing machines, and in but one-twentieth of the time necessary when the teeth are cut by end mills. The precision attained is, moreover, of a very high order.

The construction of the machine is clearly shown in Figs. 3 to 10, page 35. The base of the machine consists of two deep and rigid bed-plates, A and B, bolted together at right angles to each other. The cutters and their gear are mounted on A, and the blank to be cut on B. This blank is not shown in position in either Fig. 3 or Fig. 4, but it is secured to the end of the casting V, as shown at C in Figs. 6 and 7. The blank

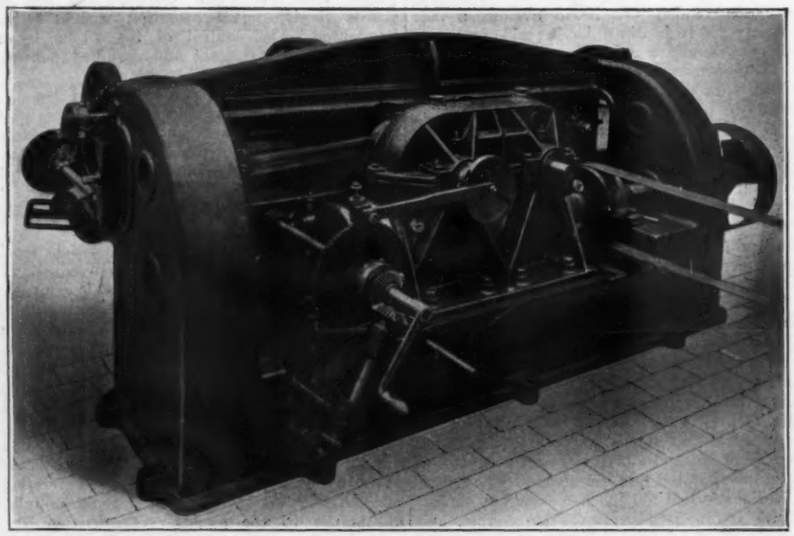


FIG. 2.

is driven round by the worm-wheel shown at D, the motion of which is derived from the change-gears represented at E.

The two cutter heads are represented at F, Figs. 4, 8 and 10; the shafts carrying them are mounted on the slides or saddles G. Each of these shafts is integral with a spur-wheel H, Fig. 9, which gears with the wheel L; the latter is integral with the rifle-bar K, which passes through a rifled hole in the worm-wheel J, Figs. 4 and 8. When the tool is in operation this worm-wheel is rotated by the bevel gear shown at I, and by the same mechanism as produces the corresponding rotation of the blank being cut. A claw clutch M of many teeth couples the driving member of these bevel wheels to the shaft N, which at the other end is connected by other bevels with the feed shaft O. By adjusting this clutch the relative angular position of the two cutters to each other can be varied as required. This feed shaft O is actuated by the ratchet wheel P, the pawl for which is driven by a link from the shaft Q. This shaft Q carries at its inner end the disc crank which actuates one of the slides or saddles G, the other deriving its motion from the shaft R. By additional bevel gearing the ratchet wheel P is coupled to the change gears E for the blank rotating gear.

The cutters, being essentially planing tools, require to be relieved on the return stroke. To provide for this the heads carrying them are pivoted or hinged, enough freedom of motion being allowed to permit of the clearing of the tool without interfering with the gearing together of the wheels H and L. The arrangement is set forth in detail in Figs. 8 and 9. To ensure a positive clearance of the tool on the return stroke the friction rods shown in Figs. 8 and 10 are provided. These rods slide in the fibre bushing shown in Fig. 10, the grip of which on the rod can be adjusted by the friction bolt shown. The resistance offered by this bushing on the return stroke swings the cutter clear of

THE SYKES GEAR-CUTTER FOR DOUBLE HELICAL TEETH.

CONSTRUCTED BY THE POWER PLANT COMPANY, ENGINEERS, WEST DRAYTON.

Fig. 3.

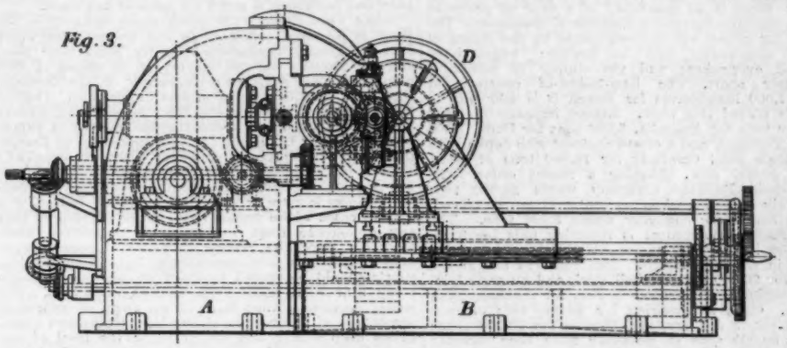


Fig. 5.

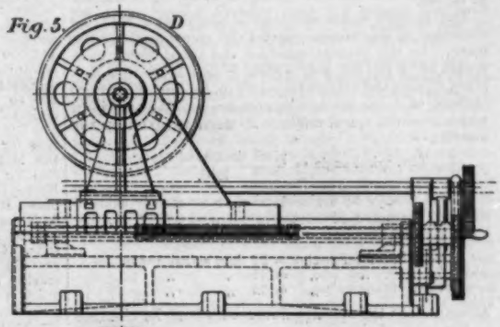


Fig. 4.

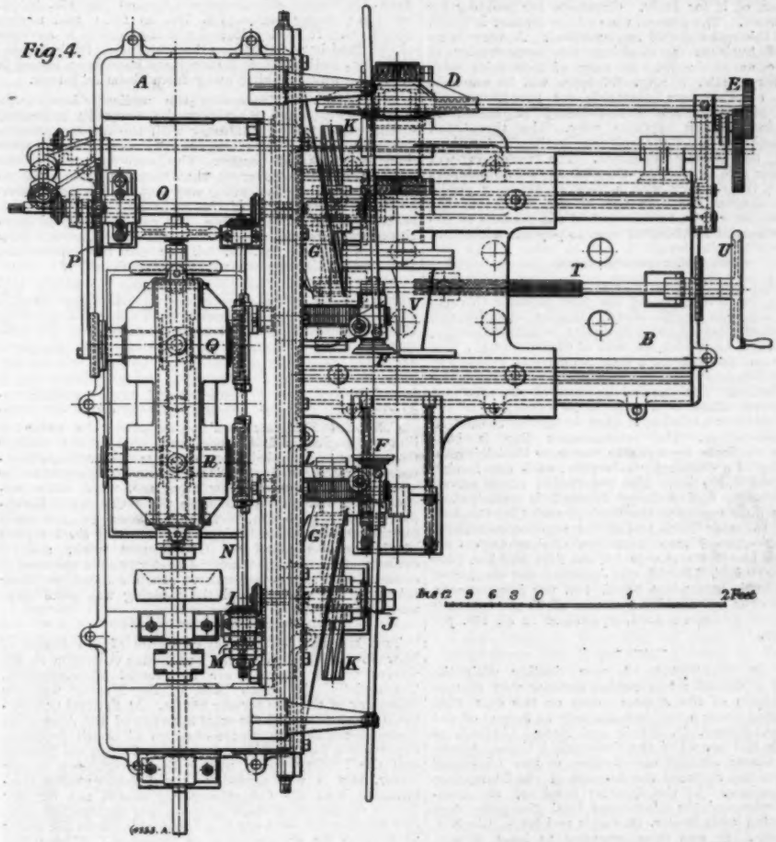
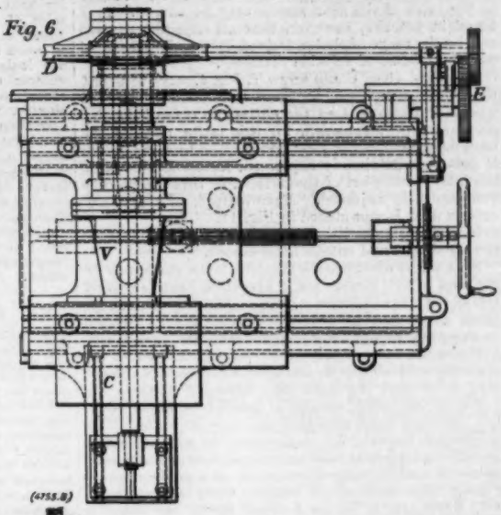


Fig. 6.



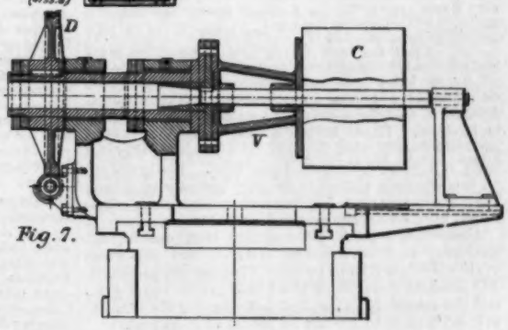


Fig. 7.

Fig. 8.

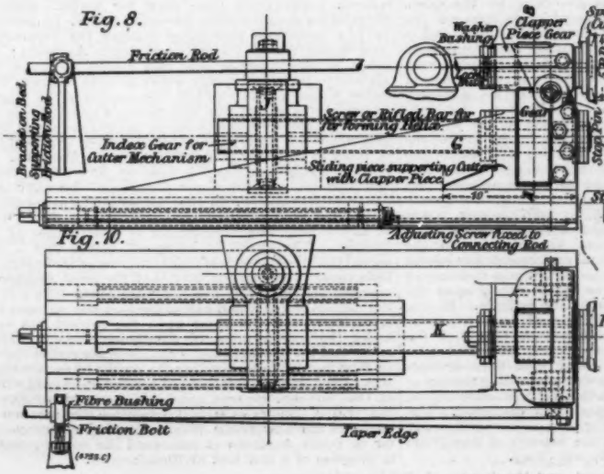


Fig. 9.

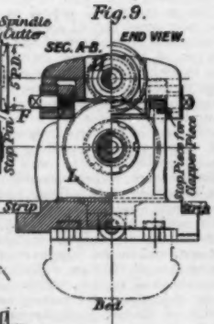


Fig. 10.

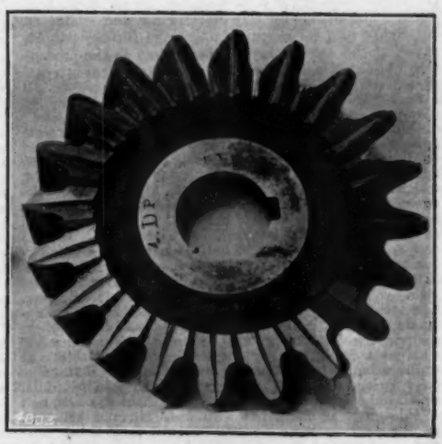


FIG. 11.

the work. To facilitate the operation of the machine the change gearing for the rotary feed is arranged so that the driving wheel has the same number of teeth as the cutter, and the driven wheel the number of teeth to be cut.

The spirally fluted rifle-bars in conjunction with the diameter of the cutters control the spiral angle of the teeth. In the present machine the spiral flutes have a lead of 74 in., the gear wheels H and L are in 2 to 1 ratio, so that the cutters travel 37 in. for one revolution. Cutters of 5 in. pitch diameter are generally used, in which case the spiral angle is 23 deg., as given by the formula—

$$\text{Tan. spiral angle} = \frac{\text{pitch circum. of cutter}}{\text{lead.}}$$

It will readily be understood that by merely using a suitable diameter of cutter any spiral angle may be obtained, for instance—

6-in. diameter cutter = 27 deg. spiral angle.
7-in. " " = 31 " "
8-in. " " = 35 " "

Alternatively the spirally fluted bars may be changed or the ratio of the gear wheels may be altered. It is found in practice, however, that all requirements are met by the range of choice derived by merely placing in position cutters of suitable diameter.

The hand wheel U and screw T, Fig. 4, serve to adjust the work-saddle to accommodate various sizes of wheels and also to feed the cutters to correct depths. An automatic mechanism for this latter purpose has been designed but not yet applied. The serrated clutch M provides, as already explained, means for breaking the inter-connection of the cutters, so that they can be independently adjusted. A photograph of one of the cutters used is reproduced in Fig. 11.

It will be gathered that the operation of the machine is very simple and entails little labour.

By a slight modification straight-tooth gears may be cut, and as two cutters are in operation simultaneously and as the range of travel is large, a quantity of straight-tooth gears may be cut at the same time. Stepped or staggered straight-tooth spur gears may also be cut. Perhaps the most generally interesting feature of the machine is its ability to cut teeth with pointed apices; that is to say, the right and left-hand portions are joined at the centre, similar to machine-moulded teeth, but naturally much smoother and more accurate. This is possible because the cranks provide a positive and unvarying travel for each cutter, and consequently each cutter is easily arranged to reverse at a predetermined point. The cutters, of course, work alternatingly, i.e., when one is on its forward stroke the other is returning. When one cutter has taken a cut, a burr or a portion of a chip is left, but the other cutter takes this off and presumably leaves another burr, to be taken off by its fellow. It would seem that finally a burr would be left, but this is not the case. This action is difficult to describe clearly, and must be seen to be fully understood. There is no doubt, however, that a perfectly smooth finish is produced without the slightest trace of a burr or blemish of any kind. The gears cut on this machine appear to be very accurate in action. They show a perfect bearing surface over their whole length and are highly polished.

About 2,000 gears have so far been cut on the machine; most of them are used on very important work where they have to meet exacting requirements. The smallest diameter of blank that can be cut is $\frac{1}{2}$ in., and the largest 25 in., so that gears having the remarkable ratio of 50 to 1 could be produced if desired.

Other machines are being made of various sizes. One is designed to cut wheels for turbine speed-reducers. Its largest capacity is 6 ft. diameter, 24 in. wide, 2 in. pitch. The cutters for this machine are 8 in. diameter. Mr. Sykes has, we learn, been granted further patents covering the application of the system to the production of double helical racks and double helical internal gears.

OUR LOCOMOTIVE EXPORTS.—Our locomotive exports appear to be still falling, the value of the engines shipped in June having been only 59,209*l.*, as compared with 227,372*l.* in June, 1915, and 308,359*l.* in June, 1914, which was one of the last complete months before the outbreak of the great war. The value of the engines exported in the first half of this year was only 586,598*l.*, as compared with 1,226,970*l.* in the first half of 1915 and 2,083,751*l.* in the first half of 1914. The value of this year's exports will be seen to have been barely one half what it was in the depressed first six months of last year. We have been sending rather more locomotives, however, to the Argentine Republic this year, the shipments to that quarter being valued at 142,168*l.*, as compared with 41,590*l.* Australia also took locomotives and parts of locomotives in the first half of this year to the value of 118,855*l.*, as compared with 35,832*l.* The most serious decline has occurred in the case of India, which only exhibits a value of 191,867*l.* in the first half of this year, as compared with 984,074*l.* and 839,064*l.* in the corresponding periods of 1915 and 1914. The war—and always the war—will be seen to have been the cause of the prevailing depression.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, June 28.

THE past week developed a slight falling off in European orders and a holding off on the part of domestic buyers; there is no possibility of a drop in prices at present, but premium prices continue to disappear. The demand for labour will be accentuated by the calling of 142,000 able-bodied men to Mexico; wages have advanced everywhere and the supply of labour is desperately short. The long-talked-of contract of 800 to 1,000 locomotives for Russia it is said will be definitely placed this week. Export inquiries for rails are 2,000 tons for Australia, 8,000 tons for Cuba, 7,500 tons for Portugal, and a closed contract with Japan with the Midvale Steel Company for 10,000 tons of plate, making 20,000 tons, including a recent order. The Pennsylvania Railroad Company wants 20,000 tons plate; Italy is buying wherever contracts can be placed. A Nova Scotia car company wants 5,000 tons. The United States Government is receiving bids for 9,000 tons. Ore is becoming scarce at Pittsburg; a strike prevails in the lake region. Two concerns are in the market for 20,000 tons of shell steel, and an export inquiry is calling for 30,000 tons of bars for manufacturing purposes. Cuba is inquiring for 60,000 tons of rails for next year's delivery, and Sweden for 10,000 tons; sales of 50,000 tons of Bessemer have been recently made, most of it for Italy. Contracts are pending for as much more. The general tone of the market is quiet, but it is the quietude of engorgement. A very large volume of business is awaiting the opportunity of acceptance at the mills. In case of hostilities with Mexico, very little, if any, difference will be made in execution of European contracts for munitions and munition material. The extraordinary expansion of capacity in progress explains why. The threatened railroad strike of 400,000 employees is the most serious factor in the labour situation. The railroads will present their side of the case through 17,000 newspapers throughout the country with a view of arousing public sentiment against the demands of the workmen, the result of which will be to take out of the pockets of the people upwards of 100,000,000 dols. to pay the additional wages.

NEW ZEALAND WATER POWER.—An Aid to Water Power Act, 1910, empowered the New Zealand Government to establish hydro-electric supply installations, and the first of these is now in operation at Lake Coleridge, in the Southern Alps, 70 miles west of Christchurch. The plant has been designed for a total capacity of 12,000 kw. (16,000 horse-power). Of this one-half is included in the first installation. The natural features of the lake and adjacent rivers allow of a very large extension of the supply; and it is anticipated that it can be carried to 58,000 horse-power. The transmission line is constructed in duplicate by separate routes to Christchurch. This permits of a continuity of supply, each line having a capacity of 7,500 kw. The population to be served is over 110,000, and a large demand is anticipated, including a bulk supply to the Christchurch City Council, and some 15 other local bodies for retail distribution. A contract entered into with the Christchurch City Council provides for a charge for the first 300 kw. (400 horse-power) of 8*l.* 13*s.* 4*d.* per kilowatt per annum of maximum load, equivalent to 6*l.* 10*s.* per horse-power, and for all over 300 kw. for a charge of 5*l.* per kilowatt per annum of maximum load, equivalent to 3*l.* 15*s.* per horse-power.

RATING OF COLLIERIES.—A case dealing with the assessment of collieries was carried another step further by the decision of the Appeal Court on the 21st ult., when judgment was given unanimously in favour of the respondents, Messrs. D. Davis and Sons, Limited, of Ferndale, in the appeal of the Pontypridd Union Assessment Committee against the decision of the Divisional Court which had reversed the decision of the Glamorgan Quarter Sessions. At the Quarter Sessions, the Cambrian Collieries and the Glamorgan Coal Company were also associated with Messrs. D. Davis and Sons, Limited, as appellants. It was then arranged to hear Messrs. D. Davis and Sons' appeal as governing all the cases. The case arose out of an agreement made between the Assessment Committee of the Pontypridd Union and a number of the colliery owners within the Pontypridd area in 1902, when the assessments of the collieries were largely increased, but were reduced as the result of successful appeals undertaken upon the advice of Messrs. Humphreys-Davies and Co., of London, the well-known firm of rating surveyors. Following the appeals, and with a view to avoiding litigation in the future, the agreement referred to was concluded by which the collieries were to be assessed on a tonnage basis which would include each colliery and its appurtenances; the agreement was to continue until either of the parties gave notice to terminate it. In 1907 a new power station was erected to replace a number of smaller stations, and in the Supplemental Valuation List for the spring rate of 1913 an additional assessment was placed upon the new station. This assessment was the subject of an objection, and failing to obtain relief, upon the advice of Messrs. Humphreys-Davies and Co. Messrs. D. Davis and Sons carried an appeal to the Quarter Sessions. It was there contended on behalf of the Assessment Committee that the Court could not take cognisance of the agreement, and that the overseers were entitled to rate the electrical generating station as a separate hereditament. The Quarter Sessions accepted this contention and the appeal was dismissed. The decision of the Quarter Sessions was, however, reversed by the Divisional Court, and the decision of that Court has now been upheld by the Appeal Court.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—The pig-iron market still remains closed, and the condition of No. 3 iron, both in store and otherwise, is much the same as last week.

Scotch Steel Trade.—The steelmaking industry in the West of Scotland continues to run on the lines which have so greatly characterised it for some time past, and the pressure for the delivery of all classes of steel required for war purposes is constantly on the increase, shells and shell bars being of first importance. Despite the difficulty of and frequent delay in obtaining licences for shipping steel, &c., a considerable amount of export business is now being put through, especially to France, the demand being most satisfactory, although practically nothing but material required for the prosecution of the war is going through. In consequence ordinary mercantile business is more or less at a standstill. Indeed, it is only in cases where urgent repair work is required that any divergence from war work is permitted, more especially since the events of last week came to be known, for it is now increasingly imperative that no efforts should be spared to speed up wherever possible every branch of trade pertaining to munitions. The recent operations must have blown away an enormous percentage of the output of our local workshops alone. Prices keep steady and are much on the level of last week, for export ship-plates are quoted 14*l.* 15*s.* to 16*l.* per ton; boiler plates, 15*l.* 10*s.* to 16*l.*; and angles, about 14*l.* It having leaked out that prices in advance of the fixed level for home rates were being freely quoted and paid, authoritative instructions have been issued in regard to any breaking away from these in future.

Malleable-Iron Trade.—In the malleable-iron trade there is no cessation of activity, the constantly increasing orders being turned out daily with the utmost possible despatch, and makers are as fully employed as their depleted staffs will permit. The home demand for the entire product is so great that there is practically no opportunity for considering any export business whatever. With so many of the mills engaged upon steel, it is practically impossible to get delivery in anything like reasonable time. Prices for "Crown" bars are still quoted 14*l.* 2*s.* 6*d.* per ton for export, and 14*l.* 12*s.* 6*d.*, less 5 per cent., for home delivery.

Scotch Pig-Iron Trade.—The demand for Scotch pig-iron continues unabated—hematite in particular being in such constant requisition and in such enormous quantity that it practically goes hot from the furnace to the steel works. With so much activity stocks in all the yards are being constantly drawn upon. Licences for makers' iron are scarce at the moment, and in consequence a better supply is now available for local consumption. Prices are still strong, but are unchanged over the week.

Controlled Establishments' Association.—In order to link up engineers and others employed in the various Government-controlled iron, steel and allied establishments throughout Scotland a meeting of representatives was held in Glasgow a few days ago, when, after discussion, it was resolved to form the "Controlled Establishments' Association." This has been decided upon for the purpose of furthering and protecting the interests of the firms engaged on Government work, and of dealing with questions which naturally arise in the altered condition of affairs generally. Much interest is being taken in the venture and the meeting was alike large and representative.

THE MURRAY.—The relative rights of the States of New South Wales, Victoria, and South Australia to the waters of the Murray are at present undetermined. Territorially, the south bank of the Murray was the boundary of the two former States. At Federal Conventions which preceded the establishment of the Australian Commonwealth the representatives of South Australia expressed a fear that too much irrigation on the Murray and the Darling might impair the navigability of the latter, and it was agreed by the Commonwealth Constitution that the Commonwealth should not by any law or regulation of trade or commerce abridge the right of a State or its residents to a reasonable use of the water of a river for conservation or irrigation. Under this section, negotiations have been for several years in progress between the three interested States. In January, 1911, a conference took place between the Premiers of New South Wales, Victoria, and South Australia; the result of this meeting was that South Australia was allowed to carry out storage works at Lake Victoria, New South Wales, and to lock her own portion of the Murray at her own expense. But New South Wales and Victoria would not recognise the claims of navigation in any way, and would not bind themselves to deliver any quantity of water at the point of intake into South Australia. No right to navigation was conceded by New South Wales and Victoria, and the upper portions of the river were left free for irrigation. In 1913 the three States appointed a Board of Engineers to make investigations with a view of ascertaining means conducive to a settlement of the question. The board, in its report, stated that it was agreed that the interests of irrigation were more important than those of navigation, and that the great expense of maintaining the latter was not warranted. The cost of the various works which were suggested was estimated at 4,663,000*l.* An agreement upon the subject has been under the consideration of the Commonwealth Parliament and the Parliaments of the three interested States. In New South Wales, pending the results of an investigation of the dam foundations of a proposed storage dam at Cumberoona, surveys are being made by officers of the Water Conservation and Irrigation Commission of lands on the New South Wales side of the Murray. So far as South Australia is concerned the construction is in progress of a first lock at Blanchetown.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—There are no new features in the returns of the traffic dealt with at the port during June. Business still further declined. The total of 283,191 tons dealt with is a reduction of 95,000 tons on the corresponding period of last year. The aggregate of 1,617,052 tons for the half-year is nearly 750,000 tons below the figure for the same period of 1915. The falling-off in the export trade is quite pronounced. The total of 73,494 tons for June is a decrease of 50,000 tons on the preceding year, and the business for the half-year of 509,098 compares unfavourably with over a million tons a year ago. France took one-half of the export total, but this section of the trade was a reduction of 56,000 tons. Italy received a large increase, viz., 16,969 tons, as against 1,005 tons a year ago. Sweden obtained 14,568 tons, which is a slight increase. The Denaby and Cadeby Main Collieries are still the chief contributors to the port.

South Yorkshire Coal Trade.—There is still great delay in the fixing up of the gas companies' contracts, which are now considerably overdue. The question of price is the greatest obstacle to a settlement, but it is expected that satisfactory terms will be agreed upon later in the week. The house coal position is still an unusually busy one for the time of the year, due, no doubt, to the vagaries of the weather. The local demand for steam fuels continues to absorb nearly all supplies available. The system put in operation by the Government appointed Committee, which deals with supplies, has ensured regular quantities arriving at the different works and for the railways. There is no question of the efficacy of the new arrangements, which make the respective collieries responsible for the fueling of the various undertakings. One result is to limit still further the amount of fuel available on the open market. Small coal is very scarce. The shipments remain at a normal figure, even though Italy is to-day a bigger customer than ever she was before. The tonnage directed to Italian ports this year has been diverted from the neutral trade. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.*

Iron and Steel.—With the expected advance in the prices of pig-iron failing to materialise there has been a much easier tone in the market, and buying has been on a heavier scale than for some time past. Munitions, however, are more and more fully swallowing up the supplies, and there is less material available for the domestic trade. Billets are still exceedingly difficult to secure. Some faith had been pinned in the possibilities of substantial American consignments with the marked reduction in freightage, but it has been found that the quantity set aside for export is comparatively small. Moreover, prices are so inflated that Sheffield manufacturers, if they did obtain considerable tonnage, could hardly work it at a profit. Two-inch American billets, it is estimated, would cost about 14*l.* with delivery here. Meanwhile very little home-made basic steel is on offer, and Sheffield is unable to do business in the cheap grades of finished steel. There is not much satisfaction to be got from a study of the Swedish position. Both iron and steel are dear and the anticipated increased shipments are not arriving. Some users manage to secure fairly large supplies, but values are high, and show no signs of decreasing. Trade in the scrap-metal market is at its busiest. Heavy steel scrap is firmer. The prices have now been fixed by the Ministry of Munitions. A reprint of the order concerning coke, iron, and steel will be found on another page. Wrought iron is marked at 6*l.* 10*s.* Owing to the enormous consignments from France to South Wales, steel turnings are a drug on the market. Waste shell bars, old rails, and crop ends are very plentiful. Electric furnaces are gaining in favour. Attention is being directed to the new type of furnace which has been installed at the large steel works of Messrs. Spear and Jackson, of Brightside. It is a Sheffield invention, and runs continually on high-speed steel. Electrically driven, it has a capacity of 5 to 8 cwts. It is claimed on behalf of the furnace that it enlarges the production, secures greater uniformity of the finished material, and has lower running expenses than the crucible type. There is at present a particularly heavy demand for high-speed steel, and although the industry is thoroughly organised, its resources are tested to the utmost to meet all the requirements of the Allied Powers. Tungsten is still a short supply. Sheffield cutlers are busily engaged upon large orders of scissors and surgical instruments for hospitals, whilst spoons, forks, &c., are wanted in countless numbers for the Army, and also for the home and colonial private trade. Messrs. Clayton and Shuttleworth, of Lincoln, have obtained an important War Office contract for traction engines. New overseas business for tools, files, cutlery, hardware, augers, steel castings, and steel, help to swell the expanding export trade.

DEFENCE OF THE REALM REGULATIONS.—Attention is called to Regulation 41A of the Defence of the Realm Regulations and D.R. Form 17 issued thereunder, by which lists of male employees between the ages of 18 and 41 must be exhibited in a conspicuous place on the premises where such men are employed. The official forms for this purpose can be obtained from any Post Office.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is on only a limited scale. Most buyers have arranged for their supplies over the present quarter, and many of them would readily extend contracts to the end of the year, but makers show unwillingness to commit themselves beyond September. Limited quantities of Cleveland pig are being released for conveyance to Scotland so that the foundries north of the Tweed shall not be dislocated. The embargo on delivery to Scotland should tend to make iron-producing districts more self-dependent. The Distributing Committee are carrying out their duties in a way that leaves little ground for complaint under the conditions prevailing. They are allocating satisfactory supplies to local consumers, and making every effort to facilitate shipments. For home consumption No. 3 Cleveland pig, No. 4 foundry and No. 4 forge, all stand at 87*s.* 6*d.*; and No. 1 is put at 91*s.* 6*d.* For export, No. 3 is 95*s.*, and No. 1 is in the neighbourhood of 100*s.* Stocks of Cleveland iron alter very little. The quantity in the public warrant stores here now stands at 28,253 tons, composed of 27,258 tons of No. 3 and 995 tons of other qualities of iron deliverable as standard. Since the beginning of the month 667 tons of No. 3 and 550 tons of standard iron, a total of 1,217 tons, have been taken from the stores.

Hematite Iron.—The East Coast hematite branch of the iron trade presents no new feature of moment. New business is quiet, but deliveries on running contracts are heavy. For home consumption and for shipment to France, Nos. 1, 2 and 3 stand at 122*s.* 6*d.*; while the general export quotation is 140*s.* and upward.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough are quite up to expectation. So far this month they amount to 18,200 tons. To the same date last month the clearances reached 18,205 tons, and for the corresponding part of July last year the despatches totalled 27,711 tons.

Blastfurnacemen's Wages again Advanced.—The average net selling price of No. 3 Cleveland pig-iron for the quarter ended June 30 last has been certified at 81*s.* 5.96*d.* per ton, as compared with 72*s.* 11.28*d.* per ton for the previous quarter—an advance of 8*s.* 6.68*d.* per ton. This carries an advance in blastfurnacemen's wages of 10.75 (10¾) per cent., raising wages from 51 per cent. above the standard to 61.75 per cent. above the standard.

Foreign Ore.—Values of foreign ore continue to move upward notwithstanding the very excellent supplies coming regularly to hand on running contracts, and the fact that most consumers now have considerable stocks. Imports to the Tees so far this month amount to no less than 122,430 tons A very firm attitude is being taken by mine owners abroad, and dealers here are asking higher rates. Sellers now regard 37*s.* 6*d.* as the minimum ex-ship Tees quotation for Rubio of 50 per cent. quality, and some of them are inclined to hold out for 38*s.* These prices are based on a freight of 17*s.* Bilbao-Middlesbrough, the figure at which controlled consumers are privileged to arrange for the conveyance of ore, but in the ordinary way in the open market steamers from Bilbao to the Tees are being fixed at 19*s.*, so that to non-controlled firms the ex-ship Tees price of best Rubio would be quite 39*s.* 6*d.*

Coke.—Coke is firm and in good request. Local requirements are large, and promise to be heavier. Average blastfurnace kinds are 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is named for qualities low in phosphorus.

Manufactured Iron and Steel.—The various branches of the finished iron and steel industries present few new features of moment. Manufacturers continue fully employed, very largely on Government work. Numerous ordinary commercial inquiries are reported. Quotations all round are strong:—Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship-plates, 11*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets (¾-in. diameter), 17*l.* 10*s.*; iron ship rivets (½-in. diameter), 18*l.* 10*s.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship-plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets (¾-in. diameter), 18*l.* 10*s.*; steel ship rivets (½-in. diameter), 19*l.* 10*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and steel joist, 11*l.* 2*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has been comparatively quiet, shortage of tonnage for prompt deliveries considerably delaying fresh transactions, while buyers have shown no great eagerness to arrange for forward business. Government requirements are reported to have been not quite so heavy, but colliery owners regard any slackness as merely temporary, especially in view of a probability of more prompt loading with the advance of the month. It is anticipated that shipments under the French exports scheme will increase as the details of the scheme are worked out; but so far as neutral countries are concerned, the authorities have shown no disposition to grant licences more readily, it being desired to reserve as much coal as possible for home consumption and allied nations. The best Admiralty large steam coal has been to some extent nominal; secondary qualities have made 49*s.* to 50*s.*; Monmouthshire Black Veins, 49*s.* to 50*s.*; ordinary Western Valleys, 48*s.* to 49*s.*; Eastern Valleys, 45*s.* to 47*s.*; best bunker smalls, 29*s.* to 30*s.*; and cargo smalls, 20*s.* to 25*s.* per ton. In bituminous coal best households have made 23*s.* to 24*s.* at the pits; No. 3 Rhondda large, 49*s.* to 50*s.*; smalls, 32*s.* to 34*s.*; No. 2 Rhondda large, 36*s.* to 38*s.*; and No. 2 smalls, 23*s.* to 25*s.* per ton. The latest quotation for patent fuel has been 50*s.* to 51*s.* per ton. Special foundry coke for export has been quoted at 62*s.* to 65*s.*; good foundry coke, at 60*s.* to 62*s.* 6*d.*; and furnace coke, at 50*s.* to 55*s.* per ton.

Great Welsh Colliery Deal.—Lord Rhondda and Mr. A. Michelson, of Cardiff and London, acting on behalf of the Cambrian Consolidated, Limited, have carried through a great Welsh colliery deal, viz., the purchase of the entire ordinary share capital of D. Davis and Sons, Limited, the outlay involved being nearly 2,000,000*l.* Messrs. Davis have owned the Ferndale and Welsh Navigation Collieries; "the deal" now carried through accordingly increases the coal control of the Consolidated from 3,000,000 tons annually to 5,000,000 tons annually. Lord Rhondda will thus have the direct control of the largest output of the South Wales coalfield, independently of other undertakings with which he is associated; and it is important to add that the coal brought under the Rhondda control comprises the best Admiralty qualities. The Ferndale collieries, which have virtually passed over to the management of Lord Rhondda, consist of eight pits in this Rhondda Fach. Messrs. Davis also held the entire share capital of the Welsh Navigation Steam Coal Company, Limited, owners of the Coed Ely Collieries, which has paid 10 per cent. per annum for many years, with a recent extra 5 per cent. Half the purchase price agreed on for the shares taken over by the Consolidated Cambrian is to be paid at once; and as regards the remaining half the buyers will pay the sellers interest at the rate of 5 per cent. per annum until the sale is finally completed. The buyers are to take all future dividends declared upon the Davis shares. The sale policy of the Davis Company will be brought into line with that of the Consolidated Cambrian, and it is anticipated that the new fusion will eventually result in a great link up with an important shipping enterprise.

Western Trade Matters.—The directors of D. Davis and Sons, Limited, with which the Consolidated Cambrian, Limited, has now become associated, recommend an interim dividend at the rate of 20 per cent. per annum for the half-year ended June 30.—A special meeting of the council of the South Wales Miners' Federation has decided to bring moral pressure to bear upon Welsh absentee miners and to impress upon them the importance of working regularly. Two new steamers, aggregating 12,000 tons and 13,000 tons deadweight respectively, have been added to the fleet of the Chargeurs Français, of which Mr. Ernest Plisson, of Paris and Cardiff, is managing director. The speed of the new steamers is 11¼ and 13¼ knots respectively. The steel steamer Bernicia, built at Middlesbrough in 1899, and 5,825 tons deadweight, has been sold to the Southern Counties Shipping Company, Limited, of which Messrs. Edwards, Hepburn and Company, Cardiff, are the managers. She was formerly owned by Mr. T. H. Mordey, Cardiff; she has been re-named by her new owners.—The directors of the Maindy Shipping Company have declared an interim dividend at the rate of 20 per cent. per annum for the quarter ended June 30.—Sir Thomas Price, formerly commissioner for railways, harbours, ports and light-houses in South Africa, is on a visit to Neath. Sir Thomas will return to South Africa shortly to take up work of another kind.—Economy continues to be enforced upon town councils by the Local Government Board. The Electrical Committee of the Bristol Council proposed to expend 27,000*l.* upon a 6,000-kw. turbo-alternator, but the Local Government authorities would only allow a loan of 16,500*l.* The committee reluctantly adopted the suggestion and accepted a tender of Messrs. Fraser and Chalmers, of Leith, for the provision of a 3,000-kw. Fraser and Chalmer's turbine, coupled to a Vickers' alternator, and with condensing plant by the British Westinghouse Company at the inclusive price of 11,608*l.*

A LARGE CEMENT FACTORY FOR AUSTRALIA.—A cement factory for Australian Commonwealth purposes is to be erected at Fairy Meadow, near Canberra, at an estimated cost of 100,000*l.* It is to have an output of 20,000 tons per annum. A deposit of limestone has already been acquired by the Commonwealth, considered to be sufficient for 75 years.

INDIAN RAILWAY ADMINISTRATION.—The construction of new works upon the Bombay, Baroda and Central India Railway has been severely restricted, not only in consequence of financial difficulties occasioned by the war, but also in consequence of the impossibility of obtaining the necessary material in Great Britain. The directors have, however, continued certain works which were in hand when the war broke out—for instance, the remodelling of some of the most important of the company's broad-gauge yards at Bandua, Ahmedabad, Baroda, &c. Some progress has been made with the strengthening of permanent way, and there has also been a further expenditure for rolling-stock. A reduction of 60,000 train miles was effected in the past year on the broad-gauge lines, as well as a reduction of 102,000 miles on the metre-gauge lines. The Madras and Southern Mahratta Railway Company has opened its Guntur broad-gauge line, 37 miles in length; and official sanction has been obtained for surveys for a small line on the East Coast. The Madras and Southern Mahratta directors consider it quite possible that they will have to adopt a heavier road, stronger bridges, and more powerful engines, as other Indian main lines have done; and the subject is receiving the general attention of the Board.

HEAVY-DUTY PROJECTILE-BORING LATHE.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, ENGINEERS, PLAINFIELD, NEW JERSEY, U.S.A.

FIG. 1.

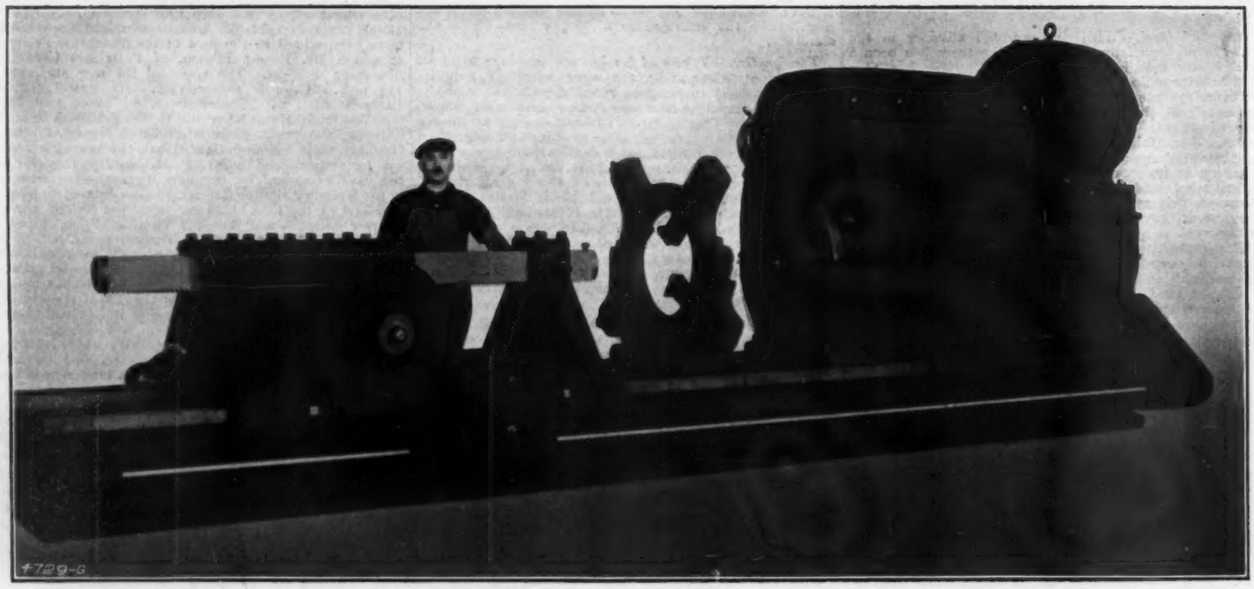


FIG. 2.

We illustrate in the views Figs. 1 and 2, above, a heavy-duty projectile-boring lathe, built, at their Plainfield Works, New Jersey, by the Niles-Bement-Pond Company, whose offices in this country are at 25, Victoria Street, Westminster. It is driven direct by a 35 horse-power variable-speed electric motor mounted on the head-stock, the latter containing all gears. The boring-ram, provided with power feed, is mounted in a long, heavy tailstock. The machine swings 37 in. over the bed and takes projectiles up to 16 in. in calibre. The American shop practice of boring large projectiles both of the high-explosive, hollow-forged type and of the armour-piercing type, demands a powerful lathe of extreme weight and rapidity, equipped with a boring-bar without cross adjustment, the interior contour of the shell being obtained by the use of bottoming and forming tools made to suit the requirements of each case. It is claimed that this method is conducive to high production, combined with economical working. The machine is easily and quickly operated; the gears contained in the headstock are either of cast or forged steel and run in oil. As will be seen from the illustrations, the head-stock is of especially massive, enclosed construction, and in order to afford a most rigid support to the spindle, gearing, and motor, it has been given a great length of bearing on the bed. Three mechanical changes of speed are provided, controlled by hand-wheels. The motor is started, stopped, and varied in speed by means of a handle which is adjustable along the bed to a point near the operator's working position. The main spindle thrust bearing is of the roller type, self-oiling, and of large diameter. The tailstock carries a square forged-steel boring-ram, having power feed by means of a shaft running along the rear of the bed, the shaft operating the ram through gearing and a worm and worm-wheel, this giving a smooth, positive motion. Large pilot-wheels are provided for the hand traverse of the ram and for starting and stopping the power feed. A positive clutch mechanism allows of four feeds without change of gears, the changes being made by two levers on the front side of the tailstock. Four additional feeds are obtained through the same clutch mechanism by one change of gears at the head end. In order to prevent any vibration of the tools, the boring-ram also runs in a support which can be adjusted along the bed to a position near the work.

THE THAMES VALLEY.—During nine official years end ing with 1914–15 inclusive, heavy rainfall was experienced in the Thames Valley above Teddington. This was a matter of some interest in connection with the water supply of London. In 1906–7 the Thames Valley precipitation was 23.09 in.; in 1907–8, 31.54 in.; in 1908–9, 24.83 in.; in 1909–10, 32.33 in.; in 1910–11, 30.49 in.; in 1911–12, 31.67 in.; in 1912–13, 33.14 in.; in 1913–14, 27.93 in.; and in 1914–15, 33.08 in. The precipitation is, as a rule, greater than that of the Lee Valley. In 1906–7 there was scarcely any difference, but in 1907–8 the Thames Valley excess was 4.85 in.; in 1908–9, 2.06 in.; in 1909–10, 3.48 in.; in 1910–11, 3.45 in.; in 1911–12, 3.99 in.; in 1912–13, 5.99 in.; in 1913–14, 3.71 in.; and in 1914–5, 4.91 in.

THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

(*For Description, see Page 29.*)

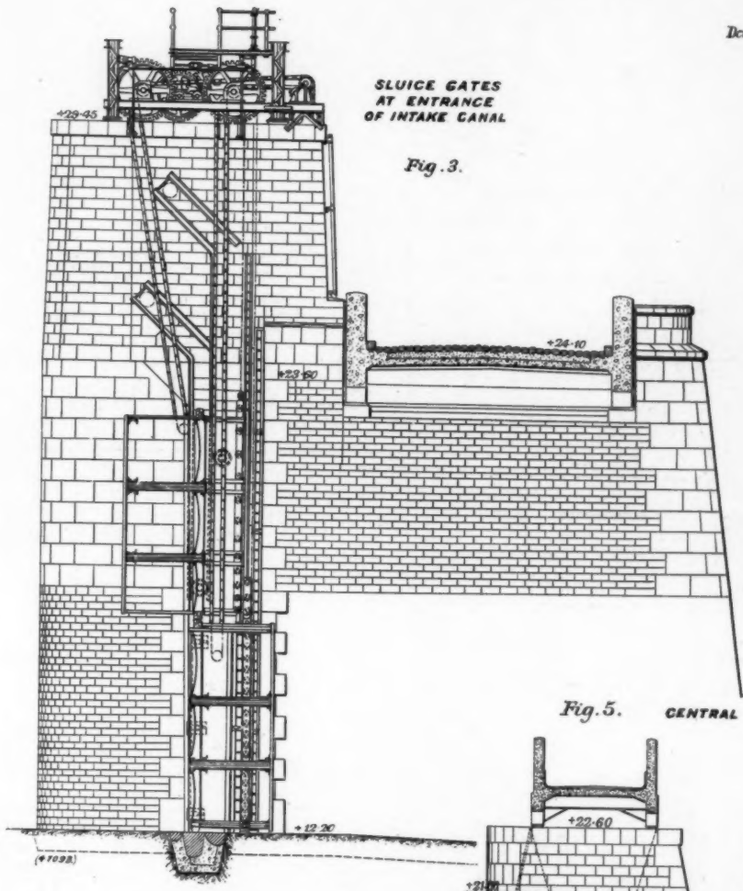
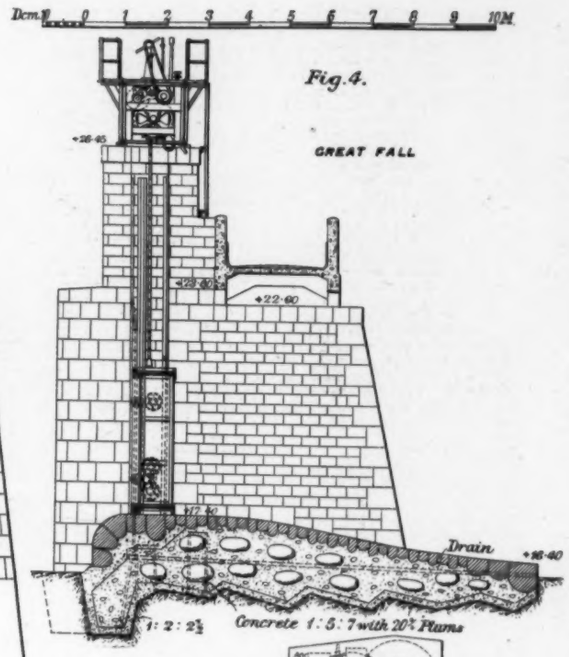


Fig. 3.



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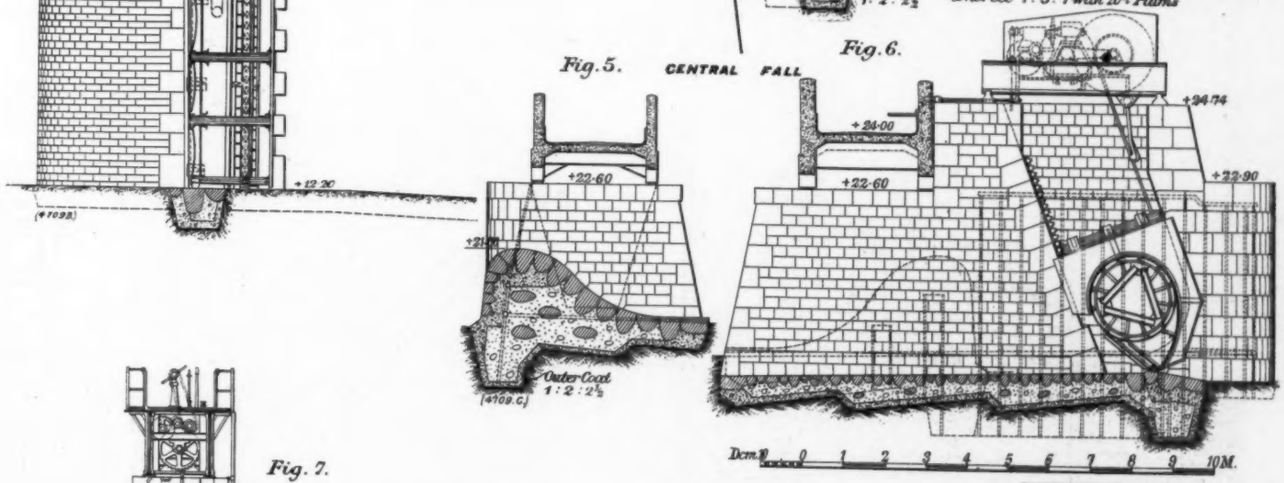


Fig. 5. *Fig. 6.*

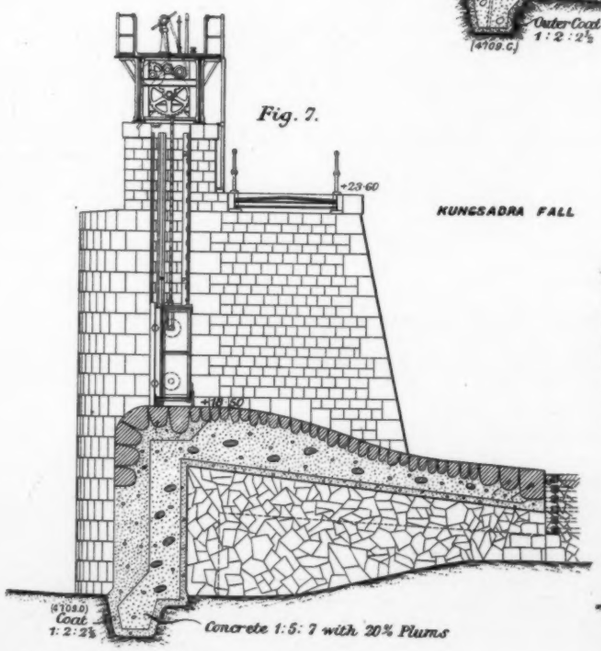
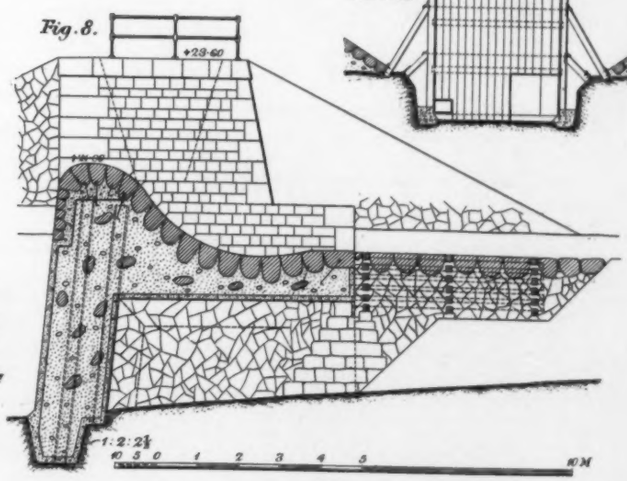


Fig. 7.



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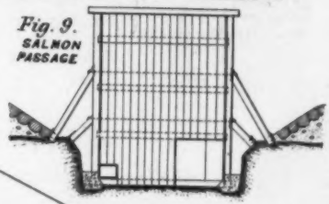

Fig. 9.

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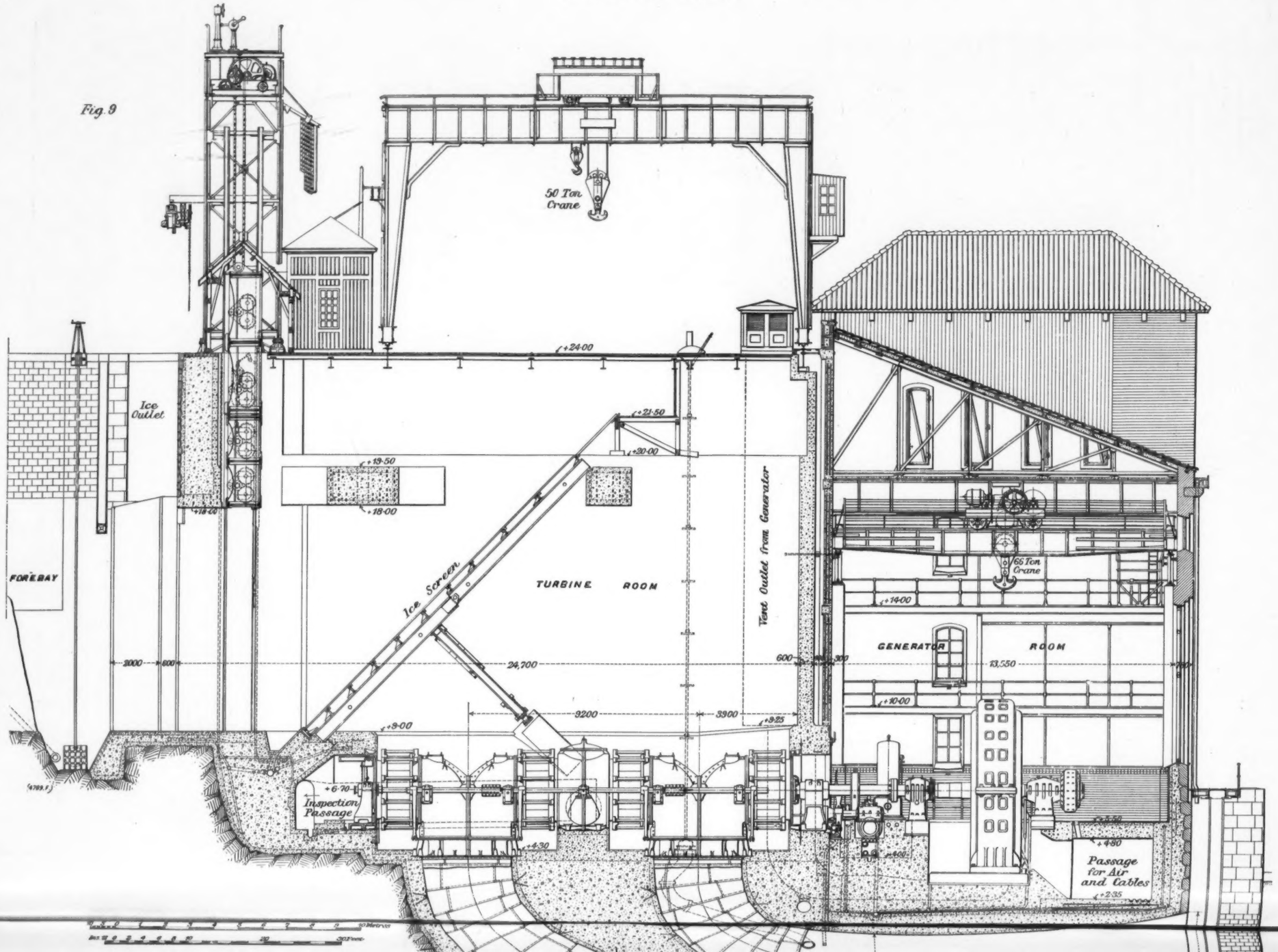
THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

(For Description, see Page 29.)

Fig. 9



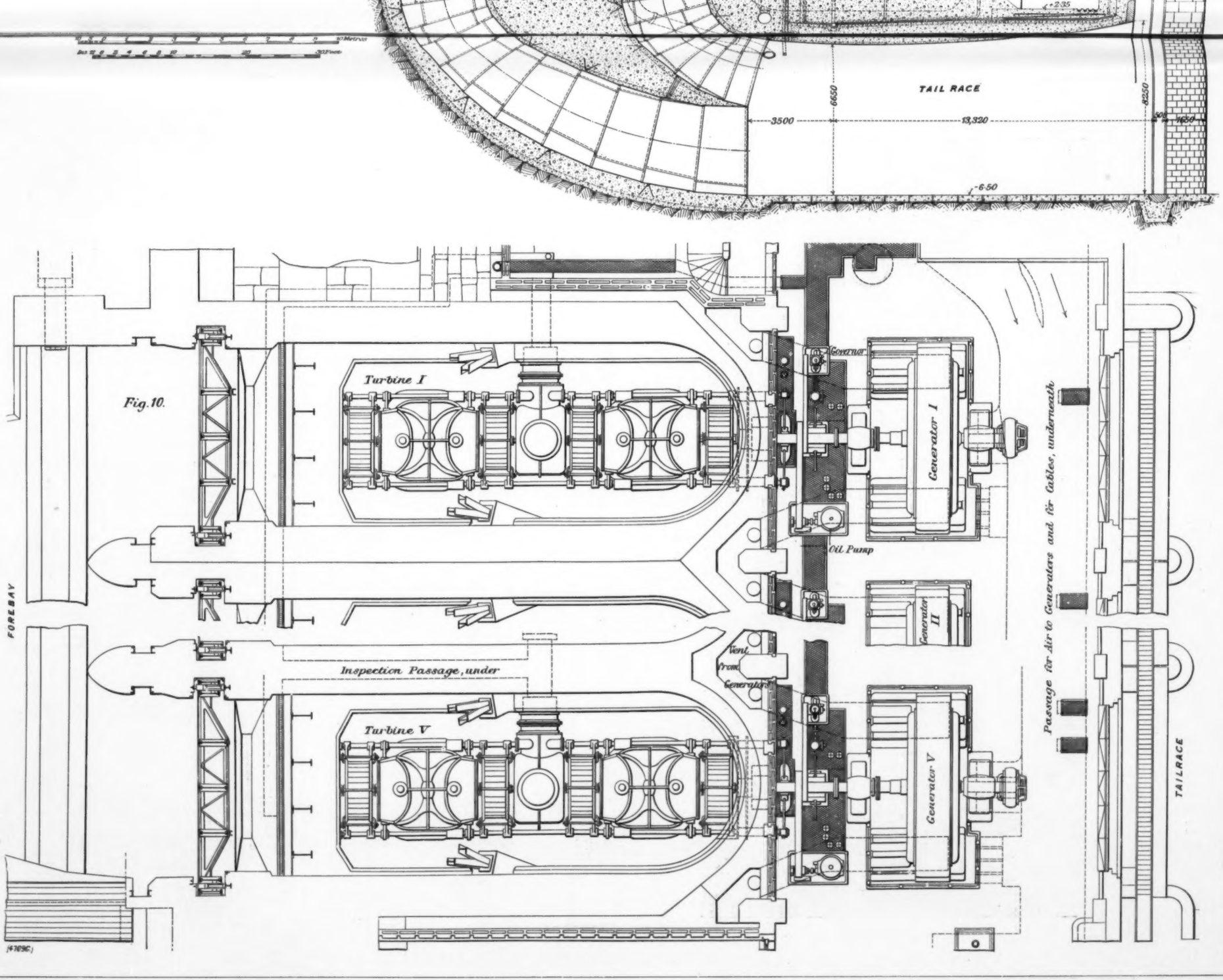

TAIL RACE
3500
6650
13,320
8250
1650
6·50
2·35
Turbine I
Governor
Generator I
Oil Pump
Generator II
Vent. from Generators
Inspection Passage, under
Turbine V
Generator V
Passage for Air to Generators and for Cables, underneath
FOREBAY
TAILRACE

Fig. 10.

THE SWEDISH STATE HYDRO-ELECTRIC POWER-STATION AT ALFKARLEBY.

(*For Description, see Page 29.*)

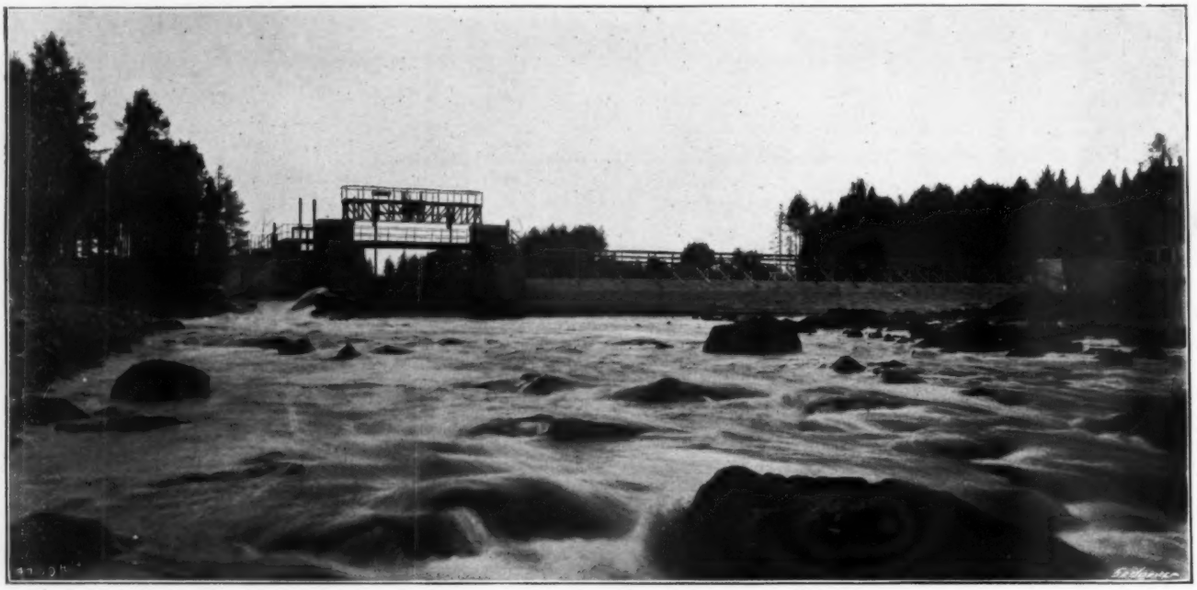
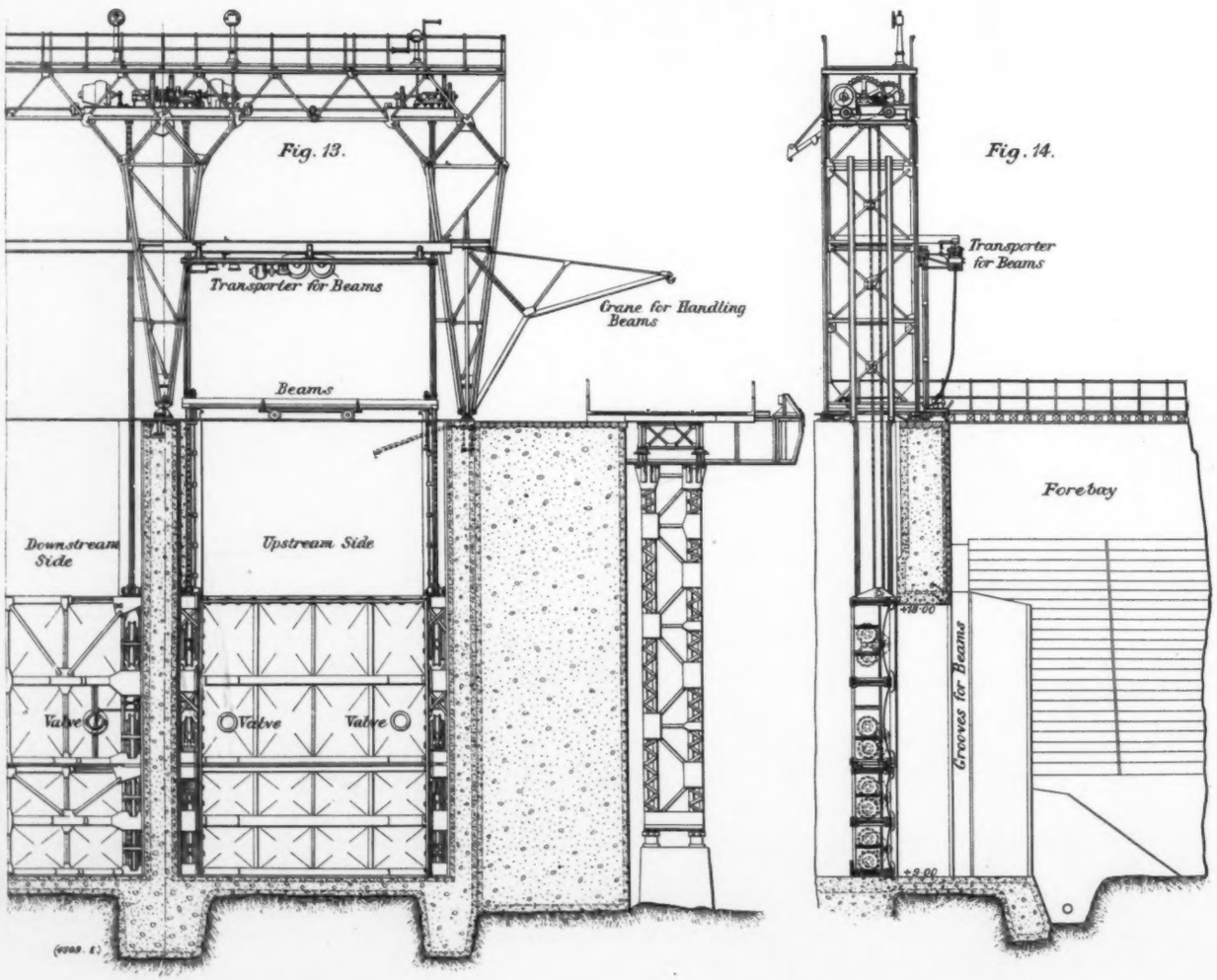


FIG. 12. DAM IN THE KUNGSADRA BRANCH SEEN FROM DOWN STREAM.



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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With One Two-Page Plate and Two One-Page Plates of the SWEDISH STATE HYDRO-ELECTRIC POWER STATION AT ALFKARLEBY.

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—Tuesday, July 18, at 3.30 p.m., at the Institute Rooms, St. James's Chambers, Sheffield. Business:—Report of the Council will be read, and election of President, Vice-Presidents, and Council will take place. The following papers will be read or taken as read:—1. "Fuel Economy at Collieries," by Mr. F. F. Mairet. 2. "Widening of the Upcast Shaft at Tinsley Park Colliery," by Mr. H. J. Atkinson, Student.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 14, 1916.

POWER-STATION PRACTICE.

THE remarkable improvements effected in power-station practice during the past few years have in the main had relation to the prime mover, such advances as have been effected in the boiler room being much less sensational in character. Fifteen years ago, for example, the plant at the 74th Street station of the Interborough Rapid Transit Company, New York, consisted of cross compound engines coupled direct to generators of 5,000 kw. capacity. The engines were constructed by the Allis-Chalmers Company to the designs of the late Mr. Reynolds, and were justly considered as representative of the best engine practice. On trial they proved capable of developing 1 kw.-hour with 17 lb. of steam, a figure which, in average running conditions, was increased to 17½ lb. The cost of this plant—engines, condensers and generators—erected in place was 40 dols. per kilowatt, and the monthly average coal expenditure for all purposes amounted to 2.5 lb. per kilowatt-hour generated. In the same station and on the same space there has now been installed a 30,000-kw. steam-turbine unit, the performance of which has recently been described by Mr. H. G. Stott, in a paper read before the American Society of Mechanical Engineers. Under test this plant has shown a thermal efficiency of nearly 25 per cent., a figure which, not many years ago, would have been considered fair for a gas engine. In average working conditions the steam consumption is less than $\frac{7}{10}$ths of that of the older engines, and the monthly average coal consumption for all purposes, including that of keeping the reciprocators hot for stand-by purposes, is 1.5 lb. per kilowatt-hour, in place of the former figure of 2½ lb. Moreover, the capital cost of the new unit (condenser included) has been but 9 dols. per kilowatt of rated capacity, as compared with 40 dols. for the old engines. The turbine is of the pure reaction type, and, together with its generator, was supplied by the Westinghouse Electric and Manufacturing Company.

The efficiency ratio attained in this case is still no doubt below the ultimate limit, but the margin for a further increase is small, and future progress, so far as the prime mover is concerned, will probably be in the direction of securing with smaller machines the efficiency figures already reached in the case of large units.

Note has already been taken of the fact that the new unit, power for power, occupies but one-sixth the space of its predecessors. Possibly something further may still be accomplished in this direction, but we already have turbines of 5,000 kw. rated capacity running at 3,000 revolutions per minute, so that here again the margin for further improvement seems small. In fact, in the case of such units the turbine proper is now becoming almost an excrescence on its own accessories, which are incomparably more bulky than the part that does the work. The whole of the blading and diaphragms of an impulse turbine of this high-speed type occupies not much more than one-third of the total volume of the casing, of which the greater portion constitutes, in fact, merely the exhaust branch. Again, the whole of the active portion of the 5,000–7,000 Ljungström turbine is included within a volume measuring some 36½ in. in diameter by about 17½ in. long.

It seems probable, therefore, that neither the efficiency ratio of the turbine nor the output per cubic foot occupied is likely to be greatly increased save by changes in other sections of the power station.

A number of turbine builders have accordingly been considering very seriously the adoption of very much higher working pressures. One of them at least, as a result of such an investigation, is convinced that it will be quite possible in this way to attain over-all thermal efficiencies in excess of those now offered by gas-engine builders, and to develop 1 brake horse-power for an expenditure of 7,500 British thermal units per hour, a common figure for gas engines being 8,000 British thermal units. Of course, for the present, this scheme exists on paper only, but that this engineer is not alone in thinking that the way to further advances lies in this direction is well shown by Mr. J. P. Gregory's interesting contribution to the discussion on the instructive paper by Mr. W. W. Lackie, which we reprint on page 47 of the present issue.

Mr. Gregory states that an over-all thermal efficiency of 19.12 per cent. has been attained at the works of the British Thomson-Houston Company, Rugby, with a relatively small unit of 1,500 kw. rated capacity, operating, moreover, with a vacuum of but 28½ in. The steam was supplied at a pressure of 350 lb. gauge and at a temperature of 700 deg. to 750 deg. F. On the other hand, a set of the same capacity, operating with the same vacuum, but with the steam supplied at 200 lb. per sq. in. and 200 deg. superheat, would have an over-all thermal efficiency of but 17.3 per cent.; the gain therefore by the high pressure and temperature is 10 per cent.

So far as the turbine is concerned there appears to be little difficulty in working with still higher pressures and temperatures, but success will probably be found to depend upon the satisfactory solution of a number of troublesome problems in the boiler-house. Water at high temperatures goes far indeed to meet the demand of the old alchemists for a universal solvent. Metals no doubt resist its action, but most other materials are rapidly corroded. Gauge-glasses are therefore likely to prove a difficulty, since even quartz is, we understand, unable to resist for long the solvent action of really high temperature water. No doubt a way out will be found, and, as a matter of fact, Dr. de Laval exhibited at Stockholm some years ago turbines operated with steam supplied at a pressure of no less than 1,400 lb. per sq. in.

Even apart from this question of the introduction of higher pressures, the boiler house would seem to present a more promising field for improvement than any other part of the power station. It is true that the advance already made has been considerable. In fact, at one large power station the average boiler efficiency, month in and month out, is greater than the highest efficiency recorded in the whole of the classical tests of Donkin and Kennedy. The improvements effected, however, have resulted in the main from the replacement of the old-fashioned fireman by the boiler-room engineer, and by the greater adoption of scientific methods of controlling the efficiency of the stoking. As Mr. Lackie points out, moreover, modifications in design have considerably increased the output of steam per square foot of floor space occupied, but this increase is in no way comparable with the equivalent change effected during the same period in the engine room.

Whilst average boiler efficiencies have increased, maximum efficiencies have remained much as they were, and are perhaps little capable of material improvement. The steam generated per square foot of heating surface, on the other hand, remains very much below what is theoretically possible. With clean metal, the heat flow could be at least sevenfold as great as is now common, without risk of overheating; but a very thin layer of soot or scale effects an astonishing reduction in the transmission rate.

Possibly the solution of the problem of attaining much higher outputs from boiler heating surfaces may ultimately be found in the adoption of gaseous firing and in the use of distilled water for the make-up feed. Both plans have other advantages, and the latter is stated by Mr. David Wilson to have been adopted in certain cases on the continent. When water contains salts in solution these are, it is found, carried over with the steam into the turbine,

where they both cause erosion and form deposits on the blades. This tends to lower the efficiency, which in some special cases has, indeed, been very seriously diminished. In this connection a point of some interest, but no doubt of minor importance, has recently been established by Callendar, who has found that when the water is not pure, drops of it pass over with the steam and can only be got rid of by a considerable superheat. The fact that superheated steam often contained water in suspension was previously known and was difficult to understand, since drops of pure water are inherently unstable and must evaporate if at the same temperature as the surrounding steam.

The incidental advantages of gas-firing are also substantial. No doubt circumstances are less favourable now than in the days when Mond gas was first applied to the generation of power. The value of the by-products was then more than sufficient to pay for the fuel from which they were derived, but the steady increase in the cost of coal will, nevertheless, make it increasingly important to recover the by-products where possible. In the discussion on Mr. Lackie's paper, Mr. Christie stated that he was endeavouring to arrange an agreement with the British Coalite Company for gasifying 200 tons of coal per day, the company taking the by-products and the Brighton Corporation the gas for firing the boilers at their power station. It is to be hoped that the scheme will prove successful, as it would mark a very important step forward in economising our natural resources.

THE GERMAN SUBMERSIBLE CARGO VESSEL.

THE voyage from North Germany to Baltimore, in the United States, of the German submersible cargo vessel Deutschland is an event of some historical importance rather than of any military significance. We need not discuss whether or not the vessel is purely a merchant ship. Whether she, on her return voyage, seriously involves the United States in a question of international law by any offensive operation, or by failing to comply with requirements as to search, need not here be considered. As to why the voyage was undertaken, it is difficult to form a definite reasonable hypothesis. In the navigation of the Atlantic by a submersible there is nothing of primary significance, because British submarine boats have made such trips and other voyages with longer non-stop runs, and during the war operations German as well as British submersible vessels have shown corresponding endurance. The transport of an insignificant volume of cargo cannot affect, from an international law standpoint, the effectiveness of the British blockade. We are forced therefore to the conclusion that the voyage was undertaken in the hope that it would impress neutral Powers, and, still more, stem the undoubtedly growing volume of anxiety in Germany regarding the immediate results of operations on land and sea. The joy with which the arrival of the vessel was heralded, according to all reports from Germany, supports this view. Thus it becomes interesting in recording the voyage as an incident in maritime history, because it is the first voyage of a submersible cargo vessel, to throw upon it the light of hard scientific fact.

The descriptions which have been cabled from America regarding the size and capacity of the Deutschland are somewhat contradictory, but they all agree in giving the displacement tonnage when on the surface as 2,000 tons, which would coincide with a length of about 300 ft. and a beam of 30 ft. Again, there is agreement as to the power of the Diesel engines with which the vessel is propelled, the brake horse-power of each of the twin engines being given as 1,300, giving collectively 2,600 brake horse-power. This, again, corresponds with a speed on the surface of 14 knots. It is comparatively easy to arrive at the weight of the cargo which such a vessel could carry, and it may at once be said that the statements of the deadweight capacity, ranging, in the first reports, from 800 to 1,000 tons, are greatly exaggerated. Later reports, however, after the drooping spirits of the German people had been revived, give the weight of the cargo as 375 tons, which is much more in accordance with the possibilities than the earlier estimates. Under the most favourable conditions regarding the disposition of weight in the ship and her machinery and stores, a greater cargo cannot possibly be carried by a submersible vessel of 2,000 tons surface displacement.

The hull of the boat, including the ballast keel, water and air service, auxiliaries, electric cables, fittings, &c., will weigh about 1,110 tons. In estimating the weight of the machinery, there is the difficulty of determining exactly the electrical equipment for propulsion when submerged, and the power available and speed attained when submerged; but even here there is room for only a slight percentage of error. Accepting the statement of the captain that he proceeded for 90 miles under water without requiring to recharge the accumulators, we arrive at the conclusion that this is the radius of action provided by the storage batteries. The machinery, therefore, including the main Diesel engines, electric motors, storage batteries and lubricating oil, works out at about 260 tons. The capacity of the fuel-oil tanks has been stated as 190 tons. The crew, the fresh water, provisions, and other stores cannot be put at less than 60 tons. The remaining demands on the weight include trimming ballast, the gun and ammunition (which, it is said, was carried for defensive purposes), and these may be taken at 30 tons. Provided no gun was carried, part of this weight may have been utilised to augment the deadweight carrying capacity. But a summation of the weights which we have given show that out of the 2,000-ton surface displacement there is left only 350 tons as cargo deadweight carrying capacity. If passenger accommodation were provided, there would be a deduction from this for the weight of the fittings, of the passengers, and of the necessary provisions and stores. The weights allowed, it may be added, give an approximate radius of action of 4,500 nautical miles at 14 knots, and 6,650 nautical miles at 11½ knots. Assuming the reserve buoyancy as 55 per cent. of the surface displacement, the displacement submerged would be about 3,100 tons. These facts somewhat detract from the practical success of this vessel as a cargo-carrier, and help to reduce to correct proportions the significance of the voyage.

EARTH RESISTANCE AND ELECTROLYTIC CORROSION.

THE amount of current leaking from an electric railway or tramway track and from other conductors depends largely upon the resistance of the earth. That resistance varies considerably, and is beyond human control, and, moreover, most soils are not homogeneous. The study has nevertheless its interest. In conducting an inquiry into the problem on behalf of the United States Bureau of Standards, Messrs. Burton McCollum and K. H. Logan (Technologic Paper No. 26) took soil-resistance measurements by three methods. According to the Wenner method a series of holes are bored into the earth with an auger 1½ in. in diameter to a depth of twice the distance between the holes; a little damp clay is tamped down each hole and the next, and a contact-piece, consisting of a bare sleeve 1½ in. long, and a plug screwed to the end of a ½-in. pipe (painted and wrapped with insulating tape) is driven into the damp clay. The measurements have several times to be repeated with interchanged and replaced electrodes, and nine sets of observations are usually required.

The second, or guard-ring method, was worked out in the Bureau by Mr. O. S. Peters. Two parallel trenches are cut in the ground, large enough for a man to work in, but leaving a thin earth wall, only a few (3 or 4) inches thick, between them, or, at any rate, between the metallic disc electrodes attached to opposite sides of the wall by means of damp clay. The one disc is whole, the other is cut up, by an annulus of insulating material, into an inner small disc of 3 in. diameter and an outer guard-ring; adjustable resistances and a telephone or vibration galvanometer bridge over the inner disc and the ring, and the resistances are adjusted until silence is obtained in this shunt circuit.

To avoid polarisation, alternating current must be used for such determinations, and the two methods above described share with other methods of observations made *in situ* the disadvantage of requiring the transport of cumbersome appliances. A third laboratory method, called the compression method, was hence tried. In this case the soil sample taken at the spot from the bottom of an excavation is at once transferred to a glass cylinder, about 3 in. in diameter. The cylinder ends are covered with mercury-sodium amalgam and copper discs, and the cylinder is then placed within a stout iron pipe to compress the plug of earth.

The results of the three methods proved to be in fair agreement, and the compression test was therefore used in examining about 90 kinds of soils from different localities. The specific resistance of the soils, it was found, ranged from 1000 to 5000 and more ohms per cub. cm. The pressure was raised up to 1000 lb. per sq. in.; a pressure of 50 or 75 lb. per sq. in was generally found sufficient for the test. High pressure should be applied slowly, but there was only a difference of about 5 per cent. between experiments finished in a few minutes and experiments lasting a couple of hours. The resistance decreases as pressure is applied up till about 100 lb. per sq. in.; then it rises, but the results are much influenced by the moisture of the soil. The dry soil has, of course, a high resistance; moisture lowers it to a minimum; the addition of more water has then little effect. Water forced out by the pressure should be removed.

The conductivity is mainly due to the salt-bearing moisture films between the solid grains, which any pressure forces into better contact. A sand which feels moist may be drier than an apparently dry clay, but a water-soaked sand will be a worse conductor than an unsaturated clay, because the clay may be rich in soluble salts which the sand does not carry. Street refuse contains much organic and inorganic matter, and made ground has a very high conductivity, partly for this reason and partly because refuse is generally dumped into moist excavations; salt marshes have low resistance for the same reasons. Rock is a better insulator than moist cement; the gravel or broken rock of railway permanent way also insulates well, unless soaked with moisture and clogged with dirt; to flush the rails in order to prevent the formation of high-resistance scale on the rail surface is undesirable in this respect, because it washes the dirt into the road bed.

The temperature coefficient of the soil is negative; above freezing point a change of a few degrees matters little, but below freezing point the resistance increases enormously owing to the formation of ice; experiments gave at — 2, — 5.5, — 12, — 19 deg. Cent. resistances (not specific) of 940, 4340, 21,700 and 49,000 ohms; the further increase at the lowest temperatures is striking. As the thawing and drying of the deep ground proceed very slowly, the weather conditions of the past weeks should be considered in determining the earth resistance. The paper to which we have referred above gives details of polarisation tests with continuous currents, which are to be continued; so far these tests have not brought out any novel points, and we hardly expect that they will prove of much use.

NOTES.

GLASGOW CORPORATION TRAMWAYS.

IT has always been recognised that the tramway system of the City of Glasgow, owned by the Corporation, was one of the most successful in the country, and the last of the annual accounts, just issued, supports this view. It is true that motor omnibuses are prohibited, that there are no electric tube railways, and that the suburban traffic on the main railway lines is of an intermittent character; so that the tramway system is advantageously situated as far as competition is concerned. Owing to the density of population, too, there is a considerable volume of traffic. Again, the lines extend long distances into the burghs that have grown up around the city. Of the 99¼ miles of streets traversed by the tramways one-fourth is beyond the city boundaries, extending into the burghs of Clydebank, Paisley, Rutherglen and Renfrew, and into the counties of Lanark and Renfrew. The average number of cars in use during the year was

650. The car mileage has steadily increased. For the year ended May last the total was within a small length of 25,000,000 miles. The number of passengers carried was 362,371,464, and the total receipts were 1,149,264*l.* There has been an uninterrupted increase almost from the beginning of the electric tramway *régime*. Last year showed an increase in total revenue of 95,834*l.* The average receipts per car-mile were 11.05*d.*, as compared with 10.61*d.* The average for the 22 years since the acquisition of the tramway system is 10.68*d.* From time to time, however, concessions have been made as regards fares, and these are probably as cheap as, if not cheaper than, on any tramway system in the country. It is an interesting fact that 42.22 per cent. of the receipts are taken in ½*d.* fares, 33.9 per cent. in 1*d.* fares, 12.35 per cent. in 1½*d.* fares, 5.01 per cent. in 2*d.* fares, 2.79 per cent. in 2½*d.* fares, and 3.62 per cent. in fares of 3*d.* or upwards. The working expenses have also increased, but not in the same proportion as the revenue, and consequently, after payments to dependants and employees serving with His Majesty's forces, there is a net balance of 383,894*l.*, as compared with 340,890*l.* in the previous year. To this there falls to be added 81,202*l.* interest on accumulated reserves. The depreciation and permanent-way renewal fund, interest on capital, sinking fund, or income tax, collectively absorb 421,549*l.*, and when this is deducted from revenue there remains a net balance of 43,548*l.* The amount borrowed as at the end of the year was 2,359,818*l.*, so that it will be recognised that the security afforded by the City taxes confers great advantage on the tramway undertaking from the capital and interest point of view. It may be added that the amount to the credit of depreciation and permanent-way renewal fund is 2,447,945*l.*, practically all of which is invested. The rates of depreciation and permanent-way renewal allowed for the year were 350*l.* per mile of permanent way, 2.9 per cent. on electric equipment of line, 2.5 per cent. on buildings and fixtures, 5 per cent. on power station and sub-stations' plant, 5 per cent. on workshop tools and sundry plant, 8.2 per cent. on cars, 6 per cent. on electrical equipment of cars, and 16.4 per cent. on other rolling-stock. The amount to the credit of the general reserve fund is 31,106*l.*; but, in addition, there is, to cover risks of accident, &c., a third-party fund.

SYNTHESIS OF AMMONIA.

The essence of the nitrogen fixation problem is that nitrogen, although a most important constituent of all the organic compounds on which the sustenance and propagation of life depends, as well as of many inorganic compounds which form the most powerful destructive agents, is in its molecular state and under ordinary conditions far too sluggish to enter into combination. Atmospheric nitrogen has to be raised to high temperatures or exposed to high pressures or powerful electric discharges before it will combine with oxygen, hydrogen, carbon and most other elements; unfortunately the equilibrium conditions of these reactions are such, moreover, that the resulting products are rapidly decomposed again unless removed from the zone of reaction. If the elements could be brought together in their atomic, active state, the difficulties might vanish. From this point of view a communication which Dr. Zenghelis presented to the Paris Académie des Sciences on June 13, 1916, deserves attention. He has tried to synthetise ammonia from the elements, using either one or both of the elements in the atomic, nascent state and in the presence of catalysts. Hydrogen is obtained in that state when generated, *e.g.*, by the dissolution of zinc in acid or by the electrolysis of water, or when occluded and reliberated by finely divided metals, especially platinum and palladium, also silver, &c., in the spongy, black or colloidal condition. Zenghelis passed, in his first series of experiments, a mixture of the gases—three parts by volume of hydrogen and one part of nitrogen—through water (acidified with sulphur dioxide in some experiments) in which the catalyst was suspended; the water was heated, but only up to 90 deg. C. Some ammonia was obtained, especially with colloidal palladium or silver as catalysts; but the yields were very poor, and electrolytic and chemically-evolved hydrogen did not give better results. In the second series of experiments the nitrogen was atomic, the hydrogen not. The nitrogen was generated from sodium nitrite and ammonium chloride; this reaction gives free nitrogen and also some nitric oxide and ammonia, which had to be allowed for in the estimates of the ammonia produced. The yields were again very low, although the experiments were continued for more than four hours. In the third series both the elements were in the nascent state, the nitrogen was generated as in the second series and the hydrogen as in the first, and then decidedly promising results were realised. The temperature ranged from 70 to 99 deg. C.; that is to say, the water was not quite boiling. If all the nitrogen had been converted into ammonia, 5,000 cub. cm. of ammonia solution should have been obtained; with spongy palladium 321 cub. cm. were actually found, with colloidal platinum 1,755 cub. cm., and with colloidal palladium 1,025 and even 2,060 cub. cm.; in the last-mentioned case there was more of the catalyst. Thus the yield came up to 40 per cent. The trouble is, of course, that the nitrogen which was converted into ammonia was generated from a nitrite and ammonium chloride, both materials at least as valuable as the ammonia to be produced. Dr. Zenghelis does not refer to this obvious point, of which he is quite aware, of course. His experiments are suggestive. But the difficulty is to find means of preparing nascent or active nitrogen. The mode of preparation to which Zenghelis resorted is the common laboratory practice; passing chlorine into an excess of ammonia is another laboratory process open to the same objection. If we can fix nitrogen only by making use of nitrogen which had been in combination and was liberated from compounds again, the outlook is hardly brightened. Perhaps the electrically-activated nitrogen of the Hon. R. J. Strutt might be utilised.

THE EARTH AS A MAGNET.

Lecturing on "Our Earth a Great Magnet"—*magnus magnes ipse est globus terrestris*, William Gilbert wrote in his famous treatise "De Magnete"—before the Carnegie Institution of Washington last winter, Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism of that Institution, gave a brief account of the work of magnetic survey done by his department, in the years 1905 to 1915, all over the world, on land and at sea. Fifty expeditions have been made to more than a hundred different countries, fully a million miles have been traversed, and measurements have been taken at 3300 stations; the instruments are carried by the Carnegie across the oceans and Arctic seas, by craft of various descriptions on rivers and along coasts, by camels across the Sahara, by lamas over the Andes, by men and beasts of burden across China and Australia, &c. The Carnegie is the non-magnetic ship of the department, a yacht of 155 ft. length and 33 ft. beam, entirely built of wood and bronze and hemp, without iron; even the four anchors are of bronze, the chain cables are replaced by hemp, the cutlery on board is of Mexican silver, and iron only enters into the construction of certain parts of her auxiliary machinery, pistons and cams chiefly; that iron makes up 600 lb., or 3 per cent. of the total weight of the machinery. The Carnegie does not make more than 100 or 150 miles a day, unless the wind is very favourable; but she has compassed the earth seven times without ever losing a man and without encountering serious mishap, although she has sailed in the Arctic seas near Spitzbergen and was at South Georgia Island on the days January 14 to 16, this year; possibly she might have assisted the unfortunate members of the Shackleton expedition if she had known of their perils. On this last journey the Carnegie failed to rediscover the Nimrod and Dougherty Islands on the South Pacific, for which Captain J. K. Davis in vain searched in 1909 when bringing back the first Shackleton Antarctic Expedition. The personnel of the Carnegie comprises twenty-three in all; the "observatories" on deck are two revolving glass domes; they serve for meteorological as well as for magnetic observations. The Carnegie has already corrected a good many errors of the magnetic charts, especially of the oceans. Running 2000 miles west from San Francisco to Honolulu, Dr. Bauer observed errors of 1 or 2 deg. in the deviation of the compass, in the same direction unfortunately for stretches of 1000 miles, so that the vessel was 30 miles to the north of her assumed position at the end of a cloudy week, during which no astronomical observations could be taken. On her first trip from Brooklyn to Falmouth in 1909 the Carnegie found similar though smaller errors even in the Northern Atlantic; sailors have often complained that a peculiar, abrupt change in the magnetic deviation occurred near Cape Race, Newfoundland, but Dr. Bauer traces the peculiarity down to errors on the magnetic charts. In the Southern Indian Ocean the errors amounted to as much as 6.5 deg., and many troubles ascribed to apparently rapid changes in the magnetism of modern steel ships seem to be due to faulty charting. Arrangements have recently been made for supplying the leading hydrographic and scientific establishments promptly with the results of the new, improved observations.

DETERMINATION OF NITROGEN IN COAL.

There are various ways of determining the nitrogen present in coal, which is of the order of 1 or 2 per cent. By the Will-Varrentrapp method and its modifications the coal is heated with soda-lime, which converts the nitrogen into ammonia. Of late the nitrogen determination of Kjeldahl (which dates back to 1883) has come more into favour also for coal analysis, and this method and its modifications have been subjected to a critical examination by Messrs. Arno Fieldner and Carl Taylor, of the United States Bureau of Mines (Technical Paper 64). A gramme of the coal (seven samples, ranging from lignite to bituminous coal, were tested), powdered to pass a 60-mesh sieve, is digested with sulphuric acid in a Kjeldahl flask, being kept at a gentle boiling heat for several hours; after cooling, crystals or powder of potassium permanganate are added; an excess of caustic soda and a few grammes of granulated zinc are then further added, and the flask is joined to a block-tin condenser which is charged with sulphuric acid to absorb the ammonia distilling over; the ammonia is finally determined by titration. Fuming sulphuric acid was originally used to ensure complete destruction of all organic matter; the permanganate favours this oxidation and transforms the nitrogen or its oxides into ammonium sulphate, which is decomposed afterwards by the caustic soda with liberation of ammonia; the zinc is added to evolve hydrogen, partly to prevent jumping of the boiling liquid. Various modifications of the method have been proposed, mainly also for the purpose of making the method applicable in the presence of nitrates and other nitrogen compounds. Wilfarth introduced metallic oxides as catalysts, later also phosphorus pentoxide; Dyer proposed mercury as catalyst; Jodlbauer used salicylic acid in addition to the potassium sulphate which Gunning suggested for hastening the oxidation of the nitrogen. Examining these several modifications, Fieldner and Taylor recommend the Kjeldahl-Gunning method with addition of mercury. They find that the addition of permanganate, in small portions at intervals, does not lead to any nitrogen losses, as had been feared, and is, on the contrary, essential even when the liquid has been digested for four hours; they had, in most cases, to continue the digestion altogether for eight hours to make sure of having attacked all the nitrogen in the coal, and it is in general advised to digest for another two hours after the liquid has become colourless. The results were checked by the method of Dumas, which is generally applicable to organic compounds. Dumas mixed the material with copper oxide and burnt it in a combustion tube, which also contained copper gauze, the liberated nitrogen being collected as such after absorbing the water, carbon dioxide, and other products of the combustion. The Dumas method is laborious, and it was known that copper oxide, especially when allowed to cool in air, would absorb nitrogen and other gases and thus falsify the results of the analyses. Fieldner and Taylor once more studied this point and found that when the oxide is used in the wire form, heated for several hours under reduced pressure and cooled in carbon dioxide, the results of the Kjeldahl-Gunning and Dumas methods agree within 0.1 per cent. and less.

LITERATURE.

The Cementation of Iron and Steel. By Dr. FEDERICO GIOLITTI, Professor in the Royal Polytechnic of Turin. Translated from the Italian by JOSEPH W. RICHARDS, Ph.D., Professor of Metallurgy, Lehigh University, and C. A. ROUILLER, Ph.D., Assistant in Chemistry, Johns Hopkins University. London: The McGraw-Hill Book Company. [Price 17s. net.]

WHEN Professor Giolitti finished his book on cementation in 1912, no branch of metallurgy was so much under the rule of thumb as cementation. To a certain extent this is still so; mysterious cements of marvellous guaranteed efficiency, but of unknown composition, are still bought at high prices, and iron is contaminated with compounds with which it should not be brought into contact during cementation, whilst science would enable the manufacturer to obtain better and more certain results with the aid of simple, inexpensive agents. Professor Giolitti is known both as a fertile investigator of this field and as an experienced metallurgist. Though he is silent on certain features—*e.g.*, on the cementation of armour-plates, as to which his views would particularly be interesting—he gives plenty of sound advice; and an English translation of his work on "The Cementation of Iron and Steel" will therefore be equally welcome to the scientist and the practical metallurgist.

The matter is dealt with in two parts, each of about 200 pages, the first on the Chemistry of Cementation Processes, the second on Industrial Applications of the Process of Cementation. In the first part, which may be called the scientific part, the line adopted is historical. A cementation process is any process permitting of carburising an iron or steel object, totally or partially, without subjecting it to fusion, by bringing it into intimate contact, at high temperature, with a cement, *i.e.*, a solid, fused, or gaseous substance from which the iron can take up carbon, which gradually penetrates into the metal. It is curious to find that the first known literature reference, in the "Pirotechnia" of Biringuccio, of Siena, 1540, describes a kind of liquid cementation process, the heating of billets of soft iron in molten cast iron. But it is pretty certain that the makers of arms, needles, &c., had, from ancient times, practised case-hardening by means of powders the composition of which remained family secrets. The science of cementation began with the classical investigations of Réaumur, who, in 1720 to 1722, presented his results to the Paris Académie. He gave a powerful impetus to the cement steel industry, which developed more rapidly in Sweden, England, and Germany, however, than in France, where suitable iron was not smelted in those days.

Dr. Giolitti traces the history of cementation in theory and practice through his first four chapters, and sums up in the fifth. Though some points require further elucidation, the researches of the last few years have cleared up many controversial problems, concerning rather the interpretation of experiments than the experiments themselves, and the conclusions of the author will probably meet with general acceptance. Powdered carbon forms the basis of most cements, but its direct technical effect is certainly negligible, though carbon alone, when kept in contact with the iron for a sufficient time at high temperature, may have a very small superficial carburising effect, even without the intervention of any gas. It is gases which penetrate into the iron. Several gases have been considered important. Nitrogen in itself and alone has no effect. Volatile cyanides might come in, because they are directly present in certain cements (as cyanides, ferro-cyanides, &c.), or because indirectly they are formed by the action of the atmospheric nitrogen on the carbonates of alkalies and alkaline earths in the carbon or in the salts added; whether the former have any specific carburising effect cannot yet be decided; the latter are certainly without influence, and the gaseous action in these cases is due to the formation of carbon monoxide. This CO has a direct effect, which is particularly intense in the presence of free carbon, and CO is the enormously preponderating factor in almost all cementation processes. It has, moreover, the advantage that its action can be properly controlled. Carbon monoxide really penetrates into the iron. In the case of hydrocarbons, this is true to a limited extent only, and hence hydrocarbons have a more superficial carburising effect. Real cementation does not appear to set in below 780 deg. Cent.

The author bases these general conclusions on a thorough discussion of all the available experimental data. More about the cements and their action follows in several divisions of the second, applied part of the book, and the reader may complain that the old conclusions are there reiterated at such a length that he is apt to overlook the additional practical points which are most important. Repetitions are a fault of the book. The first chapter of Part II. deals with total cementation of wrought iron and soft steel. Dr. Giolitti prefers high-carbon steels, obtained by melting best cemented wrought iron in a crucible, to carburising fused soft steel or to fusing cemented soft steel. The former products are more uniform, and to this feature Dr. Giolitti ascribes the recent rejuvenation of the cementation industry for manufacturing superior high-carbon steels. Wrought iron of purest quality is, in his opinion, the best material; the preference for hammered over rolled bars the author considers traditional rather. The best cement would simply be powdered wood charcoal; of additional components, alkali carbonates and chlorides are, he thinks, the most "innocuous." The so-called exhaustion of the charcoal does not take place if an atmosphere of CO is maintained in the cementation chamber. Having described cementation furnaces and their working—the operation takes from twenty to thirty days—he recommends micrographic examination as the best and simplest means of controlling the process, and he ascribes the "blisters" to the presence of slag.

The second chapter concerns Partial Cementation of Wrought Iron and Soft Steel—*i.e.*, case-hardening, cementation with solid, liquid, gaseous and mixed cements being dealt with in sub-divisions. The material in this case should be steel, rather than puddled iron or wrought iron, if the cemented product is subsequently to be fused or strongly forged. The processes are suitable for large and small objects which are not to be brittle and not subject to rapid wear by friction. The author explains the practice very fully, going into many details; but there are no explanations under the diagrams, very rarely any dimensions or scales, and one does not know, until one has read the section, whether two diagrams facing one another belong to the same furnace or box or to different appliances. The author critically discusses the solid cements in use, favouring charcoal (wood, leather, horn) and the mixture of charcoal with barium carbonate (60:40); the latter gives a very homogeneous cementation, and the cement is easily regenerated by exposure to air. Coke saturated with heavy mineral oils is a "quick" cement suitable for producing thin zones of cementation (up to 1.8 mm. thick) in a few hours. The addition of sawdust to charcoal and salt makes the cements quicker. Parts of the piece not to be cemented are covered with asbestos, clay mixed with graphite, to prevent shrinkage, or putty. If possible, and not too expensive, the parts may originally be left thicker, and then ground off before quenching, or covered with a metallic sheath of electrolytic copper. None of these protective processes are quite satisfactory.

Liquid cements are recommendable only when the cemented surface—*e.g.*, of an engraved steel plate—need not resist shock. The object is immersed in the fused cement or the powdered cement (cyanides, ferro-cyanides, ferri-cyanides, together with dextrin and other salts which the author would dispense with), and then heated. Much more important are the gaseous cements, recent in their development, and still more the mixed cements. The Machlet furnace of the American Gas-Furnace Company is combined with an apparatus in which "inert" gas is bubbled through the heated carburising liquid, petroleum, &c. The "inert" gas is, in reality, producer gas, which owes its efficiency chiefly to the CO, and the same, and better, results, Dr. Giolitti points out, could be obtained in the Machlet furnace with a mixed cement; in the latter case the decrease of the percentage of deposited carbon is not so sudden as with the former cements. Mixed cements consist of solid and gaseous constituents. We have explained already that the author ascribes the efficacy of these cements chiefly to their liberation of carbon monoxide, and he claims the following advantages for them:—High velocity of penetration, uniformity in the distribution of the carbon in the cemented zone, possibility of regulating the concentration of the carbon [by diluting the CO with nitrogen (air), by limiting the contact area between the carbon and steel, and by varying the temperature] as intended, continuous use of the same cement, absence of contamination with foreign substances; ease in keeping the surfaces of cemented pieces perfectly unaltered, of reducing deformation to a minimum, and of protecting parts not to be cemented. The last-mentioned object is secured by letting the gaseous carbonising mixture (both CO and CO_2 will be present) circulate through small ports. The author describes the muffles used for this cementation; they are generally of the vertical type, but horizontal muffles answer for rails, sectors, &c.; he gives cost estimates based on practical experience. To ensure uniformity of temperature the pieces should be preheated and the gas-current speed be kept low. The author has also experimented successfully on "expelling" the carbon from the chamber during the operation (which can easily be done with vertical furnaces), so that the gas continues to act alone (isolated gas reaction); the distribution of the carbon then becomes, with the cementations to depths of 5 mm. and 10 mm., still more uniform, and the risk of brittleness and exfoliation is minimised.

Of special processes for cementation to depths of 20 mm. and more the author says little beyond stating that the just-mentioned method of using mixed cements, with isolation of the gas reaction, gives the best results, but that he must observe silence. There are analyses of two Krupp armour-plates of chrome-nickel steel very uniformly cemented to depths of 26 mm. and 31 mm.; the process is not explained. Dr. Giolitti observes the same reticence with regard to metallic cementation—*i.e.*, the diffusion of metals into solid iron, which has assumed technical importance. According to J. O. Arnold and H. McWilliam (Iron and Steel Institute, 1899), only certain "migratory" elements (C, S, P, Ni) can diffuse into solid iron; not "fixed" elements, like Mn, Si, Cr, Al, W, As, Cu. The author questions this statement with respect to manganese and tungsten. We understand that Professor Arnold has quite recently resumed these investigations. In an appendix on Some Patents Concerning the Processes for Cementation, Dr. Giolitti refers to patented novelties which appear suggestive, but which he has not been able to test.

The remaining chapters concern Thermal Treatment of the Cemented Products (not differing from general heat treatment), and Methods of Control (Raw Materials, Temperature of Cementation and Quenching, Course of Carburisation, Cemented and Hardened Products). The author favours micrographic study (after etching with picric acid or nitric acid; other agents are not mentioned)—in addition to pyrometric studies, &c., of course—and he emphasises as most essential that bars for shock tests should be taken entirely from the core of the cemented specimen, and should not contain any part of the carburised zone.

The two translators so divided their labour that Dr. Rouiller did the bulk of the translation, and Professor Richards took the responsibility for its metallurgical accuracy. Occasionally the reader cannot help noticing that he is studying a translation, not an original book. The index, we regret to state, is not so complete as it should be.

Rural Sanitation in the Tropics, being Notes and Observations in the Malay Archipelago, Panama and other Lands. By MALCOLM WATSON, M.D., C.M., D.P.H. London: John Murray. 1915. [Price 12s. net.]

THERE are those, perhaps, who think that with the recent brilliant discoveries of Sir Ronald Ross and others the *role* of the scientific sanitarian is ended. To have traced the propagation of malaria and other tropical diseases to the action of the mosquito was a great advance, but it was only the beginning of that sanitary activity which is destined to yield such a bounteous return by facilitating enterprise

in tropical countries. The real difficulty that faces the medical authority, whose position is often isolated and work hampered by inadequate funds, is to turn Ross's discovery to practical account. Each district requires its own treatment, producing, it may be, its own special variety of mosquito, and acquainted with only the main fact that in these pests lies the key of the situation, how is he to determine the measures that should be adopted under new and untried conditions, or devise means to detect and baffle the habits of different kinds of mosquito, who display a subtle ingenuity in circumventing the clumsy stratagems of man? Success, great and lasting, will be gained only by building on the tested experience of all. Each one who approaches the subject should be placed in an advanced position by the experiments and knowledge of his predecessors, and on this ground we welcome with satisfaction this instalment from Dr. Watson, who has not only worked long and intelligently in his own district, but has compared his results with those of others at work in different parts of the world, thus broadening the foundations of sanitary science and facilitating the general advance.

Dr. Watson's proper field of work was in Klang, Port Swettenham, and a large section of the Malay Peninsula. The history of what has been accomplished in this fever-stricken district is as remarkable as it is promising. There is a slight tendency in these days of stress, when mental capacity is displacing routine, to admit that scientific investigation has been of some advantage to the nation, that research has opened new avenues to capital, and to allow that intelligent inquiry, if not too troublesome, may be encouraged. The progress effected in the Malay Peninsula should strengthen these views. The improvements that have rewarded scientific work on malaria, as recorded incidentally in this volume, should go far to support the more liberal attitude now grudgingly accorded to science. Forty years ago the Malay Peninsula was the home of a few backward people, who supported a miserable existence on a few grains of rice and bunches of fruit, possessing no property and no energy, but at times indulging in piracy and marauding adventures. Chinese immigrants gathered a little tin from the soil, or dredged from the rivers, but of trade there was little or none. Then came British protection, and the country improved, but the toll of life was heavy and it was not a white man's country. But science taught the necessity of ridding the country of the mosquito, and showed how it could be done. Miners, white and Chinese, flocked into the district, and wealth grew "beyond the dreams of avarice." In the space of a single generation the country became one of the most prosperous on the globe. Towns with well-built houses, broad streets, and pure water supplies have sprung into existence. "There are schools for children, hospitals for the sick, and pure justice for the litigant and the lawless, while posts, telegraphs, roads and railways, second to none in cheapness, link up the whole land."

To accomplish this happy result, the fight against malaria has been strenuous and insistent. The author began the campaign against the insidious foe in 1901, a time when the epoch-making discovery of Ross concerning the spread of the disease had been confirmed, but when little was known of the proper preventive methods to be adopted. Ross favoured plans aiming at mosquito reduction; the Italians placed faith in mechanical prophylaxis by mosquito netting and the use of quinine: Koch specially recommended the use of that drug. Worst of all, little or nothing was known about the different species of anophelines, and the importance of species had not been recognised. At the author's station of Klang, the work of eradicating malaria seemed well-nigh hopeless, where "no hot or cold season even temporarily stopped the mosquito pest, and every well, ditch, and swamp teemed with larvæ." Moreover, there was an ignorant and bigoted population wherewith to contend, rendering the adoption of some alternative methods impossible, but fortunately leaving open the one avenue of mosquito reduction, which practically proved the right one.

By energetic, well-directed work on drainage, by segregation of the native population on sanitary areas, the general health was so improved that the admissions to hospitals in Klang and Port Swettenham fell from 610 in 1901 to 23 in 1905, while at the same time in other portions of the district the hospital cases rose from 197 to 353. The severity of the disease in 1901 was of so pronounced a character that at Port Swettenham the work of the Harbour Department and of the railway could not be carried on satisfactorily, and the High Commissioner ordered the port to be closed till it should be made healthier. There was a notable improvement in health throughout the whole district, which, however gratifying, was not easy to explain. The solution of the riddle is probably to be found in the fact that many suffered from the sequelæ of malaria without having exhibited the peculiar symptoms of the disease, and in a weakened state of health fell easy victims to abscesses, diarrhœa, dysentery, &c.

There is no need to urge the value of such remedial measures, or the desirability of enforcing necessary precautions, but Dr. Watson drives home the pecuniary importance of the result by reminding us that the waste of only a cent a day on each coolie of a labour force of 40,000 amounts to a direct loss of 15,000*l.* per annum. Against this sum, or the actual saving, whatever it may be, is to be placed the cost of drainage and of filling up swamps, amounting, at Port Swettenham, to about 9300*l.* But a balance cannot be struck so readily as those figures would suggest. We have to take into account the scientific training that arranged the various methods of dealing with the port under many and varying conditions. Sometimes on high ground, at others in flat, swampy country, or by the side of streams and in clearances in the jungle, the danger has to be sought and worsted. Each situation demands its own remedial measures, and, further, we should acknowledge the entomological skill that renders it possible to track down the various species of mosquito, note their habits, and devise plans for their destruction. Sometimes it was necessary to carry streamlets underground, sometimes the only available plan was to alter the composition of the water in the hill streams, so as to make it an uncongenial habitat for all malarial mosquitoes. Untiring watchfulness and prompt ingenuity had to be ever on the alert. The prize was great, and it is well that those who may be inclined to undervalue research should be reminded, when they draw dividends from plantation rubber companies, that the success and economic importance of the rubber industry are due to the devotion and sacrifice of a class of men of whom Dr. Watson is so worthy a representative.

We would like to tell the tale of the beri-beri disease, whose cause was as mysterious, and action as deadly, as in the case of malaria, and where science has won a victory as thorough and gratifying; but these details belong rather to medical journals. For a similar reason we do not follow the author in his journey through many of the tropical regions of the globe, collecting from medical men on the spot their views of malaria, comparing their experience in combating the fell scourge with his own, noting the coincidences and differences, and tracing the effects of local environment. Sumatra, Hong Kong, British Guiana, and Barbados were all visited in turn, while nearly half the book is devoted to a description of the methods pursued at Panama, that finest example of sanitary work, where one of the most pestilential spots in the world has been rendered as free from disease as most places, even in temperate zones.

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Brassey's Naval Annual, 1916. Conducted by EARL BRASSEY, G.C.B., D.C.L. Edited by JOHN LEYLAND. London: William Clowes and Sons, Limited, 31, Haymarket, S.W. [Price 10s. net.]

THE LATE PRINCE B. GALITZIN.—Prince Boris Galitzin, who, we regret to hear, died in Petrograd on May 4, was one of the first authorities on seismology and was the inventor of a seismometer which is considered the most scientific instrument of its kind. His name has often been mentioned in our columns in connection with the British Association Report on Seismology and cognate researches. He was professor of physics at the Imperial Academy of Sciences.

THE MANNING OF THE MERCANTILE MARINE.—It cannot be too strongly emphasised, says the *Marine Journal*, New York, that in the present war the Governments engaged have no use in their ships for officers or seamen not of their own nationality. It is related that only a little while ago the American master of a great Transatlantic ship under the British flag was given the choice between surrendering his command and renewing British allegiance. The German-born captain of a British steamer arriving on our coast recently was promptly deposed by orders from home, though he had for many years been a British subject. This may seem a harsh policy, but persistence in it is the unmistakable purpose of the British Government. Considerations of national safety imperatively over-ride all other considerations. None but Britons, or Frenchmen, or Russians, or Italians, as the case may be, are entrusted with authority on ships of their own flag. The merchant service in time of war must be almost as rigorously guarded as the naval service.

THE LATE MR. S. T. DOBSON.

We regret to record the death by accidental drowning at Poole Harbour of Mr. Sydney Thornton Dobson, who was known to many of our readers as the engineer of the St. James' and Pall Mall Electric Light Company, Limited. He had held this position for 27 years, practically since the inauguration of the company. When the demands upon the stations outgrew their capacity the Central Electric Supply Company was formed by the St. James' and the Westminster Electric Supply Corporation to furnish a bulk supply to both, and to the undertaking Mr. Dobson and Sir Alexander Kennedy were joint engineers.

Twenty-seven years form a large proportion of a life, which commenced in 1866, and leave very little to record of the earlier period. Nevertheless, Mr. Dobson crowded as much experience into that time as was possible. After leaving King's College School he was engaged with Messrs. Edmunds and Goolden, a part of the time being spent at the Health Exhibition where the firm were showing the Hochhausen plant. In September, 1884, he was apprenticed to Messrs. R. E. Crompton and Company, working for a time under Mr. James Swinburne. In 1887 he was second engineer to the Crompton electric light plant at Tilbury Docks for a few months, and then he went to Vienna to the central station of the Imperial Continental Gas Association, a position he held for about two years.

Mr. Dobson became a Member of the Institution of Electrical Engineers in 1889, and was for some time on the Council. He became an Associate Member of the Institution of Civil Engineers in 1891, and a full Member in 1898. His sudden death will be greatly regretted by his numerous friends.

INDUSTRIAL NOTES.

It is customary in Scotland for the miners, iron, steel and other industrial workers to take their annual holidays in July. The question was discussed at a joint conference of the Coal Mining Organisation Committee and representatives of the Ministry of Munitions, Scottish Coal Owners and Miners, held at the Home Office on the 6th inst., and it was unanimously agreed that in view of representations made by the Ministry of Munitions as to the pressing necessity of the moment, it was essential in the national interest that the July holidays be postponed. It was further agreed that immediate steps be taken locally by the coal owners, in co-operation with the Scottish Miners' Union, to carry out this recommendation.

The Minister of Munitions announced, on the 7th inst., that in the exercise of his powers under Section 6 of the Munitions of War (Amendment) Act, 1916, he has made two Orders regulating the wages of women and girls employed on munition work. The first Order prescribes rates of wages for girls employed on munition work of a class customarily done by men, and will be applied to the same establishments as the corresponding directions already issued for the remuneration of women employed on that class of munition work. The second Order prescribes rates of wages for women and girls employed on munition work of a class not customarily recognised as men's work, and will be applied forthwith to controlled firms in the main munition areas engaged in the production of armaments, ammunition and ordnance and in all branches of mechanical engineering and shipbuilding. The case of other areas and trades is under consideration.

Meetings of the General Federation of Trade Unions were held last week in Leeds, under the presidency of Mr. James O'Grady, M.P., and were attended by 10 delegates from France, 2 from Belgium and 5 from Italy. One of the delegates from Belgium, Mr. Gaspar, representing the Liége Metal Workers, stated that the skilled Belgian arsenal operatives were seized by German soldiers and brought to the side of the machines they were in the habit of working, and on the men refusing to work they were flogged in the presence of their wive and children previous to being sent to prison in Germany. A French delegate, Mr. Jouhaux, Secretary of the French Federation of Trade Unions, predicted that the war would bring closer together the workers of England and France and would have the effect of developing and strengthening their organisations. Colonel John Ward, M.P., in moving a vote of thanks to the foreign delegates said that the unions must insist upon having some voice in the peace conditions and must combine their forces to elevate those who were lower in the social scale and give greater opportunity to some of our Allies for free development in the future. The rise of a country did not decide its greatness; Belgium was a proof of that. Mr. Ben Tillett stated that we had not only our own liberties to defend, but also the liberties of our Allies; he believed, further, that we were defending even the liberties of the German workman, who would live to bless us for having stood against Prussianism and despotism and all the de humanising forces which existed in Germany. In the course of his address at the closing meeting, Mr. O'Grady said that the membership of the Federation was 1,076,000, and the reserve fund 135,288*l.* He suggested that the safety line in finance was a reserve of 500,000*l.* This year's contribution to the reserve fund was 50,000*l.*, largely owing to the fact that there had been only 176 disputes, as compared with an average over five years of 651 annually. The falling-off indicated that the Federation had responded heartily to the appeal of the Government and had endeavoured to have as little friction as possible during the war.

An interesting addition to the ranks of munition workers, says the *Sheffield Daily Telegraph*, is a party of between 50 and 60 Australians, who arrived in London this week-end. They left Melbourne on May 24, bound for Plymouth, and the party would have been larger had there been more room on the ship.

These men are no strangers to England. Many took part in the landing at Gallipoli, and had been in hospitals over here before being sent back to Australia. They were all either fitters or turners, and, though unfit for further active service, they felt that they could still assist by making munitions.

One of the party on landing informed a representative of the Press Association that at present there are in Australia 70,000 efficient men with at least 14 months' training waiting to come over. The question of transport presents certain difficulties, but the enthusiasm of the commonwealth is unbounded. Even men of 60 are offering their services for any kind of work which may be of use to the Empire.

Speaking at the annual conference of the Miners' Federation at Buxton, last Tuesday, Mr. Robert Smillie, President, expressed the hope that before another conference came round a peace would be proclaimed which would ensure that never again in the history of the world would such a tragedy as the present war occur. No patched-up peace should be agreed to. He claimed that the rank and file of their organisation had done everything in their power to carry out honourably the pledge given to the nation to secure the largest possible output of coal from the mines of the country. In regard to the use of stone-dust for the prevention of colliery explosions, the Federation were convinced that they were making progress and the Government would, within a very short time, introduce rules which would make collieries considerably more safer than they had been in the past. With reference to the wages question, he asserted that while it was true that wages were, generally speaking, higher than they had ever been in the history of mining, in no mining district had the increase in wages kept pace with the advanced cost of living. Speaking of the formation of the "Triple Alliance" of transport workers, railwaymen and miners, Mr. Smillie stated that anything like sudden demobilisation after the war might be a very serious thing to the men employed in those industries, and they were going to approach the Government and ask them that arrangements be made to prevent an enormous number of their men coming back from being out of employment after the war; he added that the Government must assure employment or State maintenance until employment can be found for the returning men.

Mr. F. Hall, in moving a vote of thanks, expressed satisfaction with the result of the efforts made to reduce wilful absenteeism from the pits. In some cases, he said, absenteeism had been reduced to ½ per cent., and at some pits there had not been a single man absent during a whole week.

A number of delegates of the Empire Parliamentary Association, statesmen from South Africa, Australia, Canada, Newfoundland and New Zealand, were received by the Lord Mayor of Sheffield last Tuesday. They subsequently visited different Sheffield works, including those of Messrs. Hadfield, Limited. In the course of an address to the delegates, Sir Robert Hadfield stated that before the war his works did a large amount of work for the Admiralty, but had not received a single order from the War Office for six years before the war started. At the present time their commercial output was only 10 per cent., as against 90 per cent. before the war. The works now covered 100 acres and gave employment to about 15,000 workpeople, including a number of women. He took that opportunity for saying that every credit was due to the women of England for the noble manner in which they had risen to the occasion. Sir Robert upheld British science, adding that we in this country had little to thank the foreigner for; the opinion that Germany supplied a large amount of technical aid outside her borders did not hold good with regard to the majority of Sheffield work. If there had been any deficiency in the past in regard to scientific development in this country, it had been largely due to lack of appreciation by the State. For the future, our programme should include encouragement of science by the State, the grappling with bounty-fed competition, and the tackling of railway rates, and in Sir Robert's opinion the last problem would be settled by making the railways State-owned.

The *Newcastle Daily Chronicle* states that a proposal for the elimination of all competition amongst trade unions has been issued by the Executive Committee of the Amalgamated Society of Carpenters and Joiners to the union members. To achieve this object a national organising committee is suggested, in order that overlapping may be avoided and full co-operation assured. The appeal contains the following:—

"We believe that immediately the war ends, the struggle on the industrial field between capitalism and labour in almost every country in the world will begin. We are convinced that the future will bring us face to face with problems different from any that we have previously experienced, and therefore it behoves us to make preparations.

"Our members should insist on the trades councils beginning now a big organising campaign among all sections of our fellow-workers. The machinery of all working-class organisations should be strengthened in every possible manner. The stronger we are numerically the more capable we shall be of protecting our interests when the change from war conditions takes place. There are over 8,000,000 of non-union workers (men and women) in these islands, and it should be the business of the trade unionists to see that a national campaign is carried on by those responsible for the conduct of our industrial affairs.

"The trades councils could begin locally and the unions should request the Trades Union Congress to call together the executives, so that they can discuss and decide on the best methods to adopt in support of the effort that should be made. Money is badly spent because of the overlapping which takes place in this work of organising. We must insist on co-operation taking the place of the competition which exists amongst unions."

THE METAL TRADE OF KOREA.—According to the *London and China Telegraph*, the value of metal and metal manufactures imported into Korea in 1915 was 408,113*l.*, as compared with 505,793*l.* in 1914, and 498,717*l.* in 1913. There was a decrease in the imports of iron bars and rods, galvanised sheets, pipes and tubes, and steel bars, rods, plates and sheets. In iron nails, however, there was a better showing, the principal gainer being the United States with an importation of 14,126*l.* The trade in iron-wire nails is worthy of the attention of United Kingdom manufacturers; the United States Steel Trust is endeavouring to extend its trade in this article.

TUNGSTEN.—The Hansa Mines, Limited, an Argentine undertaking, produce about 50 tons per month of tungsten ore, and until the outbreak of the war their whole output was shipped to Germany. The mines have been largely controlled by German owners, reported to be associated with the Krupp company The total Argentine exports of tungsten ore from 1909 to 1913 inclusive were 3,319 tons, of which 3,309 tons went to Germany and 10 tons to Great Britain. In 1915 the United States became an importer and took 135 tons. Upon the outbreak of the war, which cut off the German market, part of the plant of the mine was closed down. Now, however, the mines are working at their full capacity, and it is announced that the entire output for 1916 has been disposed of to American producers.

"ALL THE WORLD'S AIRCRAFT, 1916."—This, the seventh edition of the World's Flying Annual, founded by the late Mr. Fred T. Jane under the title of "All the World's Airships," is issued by Messrs. Sampson, Low, Marston and Co., Limited, at 21*s.* net. In view of the large part played by aircraft in the war, the book will be studied with very considerable interest. There is an attempt to give a record of aeroplane and airship construction in all countries of the world, but obviously this is unavoidably incomplete so far as the belligerent countries are concerned, although so far as enemy nations are concerned the editor is to be congratulated on the extent of the information he has been able to gather together regarding the design of airships and aeroplanes. In connection with British aviation, it is interesting to note the steady increase in the number of aviation certificates granted by the Royal Aero Club of the United Kingdom. Up to the end of 1910 the number was only 45; in the following year this had increased to 168; at the end of 1912 the number had advanced to 382; the following 12 months resulted in nearly doubling the figures, the total becoming 719; 1914 brought the total to 1,032; while 1915, with its great demand for patriotic action, found the total increased to 2,253. There is in the book an historical record, with illustrations, extending back 14 years, of great interest, but somewhat robbed of its full value by the fact that the illustrations are not arranged in chronological order, while in many cases dates are omitted. A third part of the book deals with the world's aero engines, and is contributed by the Technical Editor, Mr. C. G. Gray, of *The Aeroplane*. Illustrations and particulars of a great many aeroplane engines are given. The same writer adds an article on aircraft in war, and notes are also given on component parts and other subjects.

OFFICIAL MAXIMUM PRICES FOR COKE, IRON, AND STEEL.

THE Minister of Munitions gives notice, under date July 7, that he hereby permits all persons until further notice (*a*) To buy, sell or deal in; or (*b*) offer or invite an offer or propose to buy, sell or deal in; or (*c*) enter into negotiations for the sale or purchase of or other dealing in certain war materials, subject to the following conditions:—(1) This permit shall not affect the provisions of Regulation 30 (B) of the Defence of the Realm (Consolidation) Regulations. (2) No sale or purchase of material in the United Kingdom not being under a contract in writing entered into prior to the date of this notice shall be at a price exceeding the prices specified in the Schedule hereto with reference to the respective classes and descriptions of material therein referred to, provided that this condition shall not apply (1) to a sale or purchase under a special permit granted by the Minister of Munitions, or (2) to a sale or purchase which is not a transaction or one of a series of transactions involving the sale or purchase of more than 5 tons, or (3) to any sale by a manufacturer of finished steel rolled from steel purchased by him, or (4) to a sale or purchase of material the export of which has been duly sanctioned. (3) Upon any such sale or purchase the seller and purchaser shall comply with any directions, whether of general application or otherwise, which may from time to time or at any time be given by the Minister of Munitions with regard to the use or disposal of the said war material.

The Schedule above referred to is as follows:—

Maximum Prices.	Per ton net. f.o.t., Makers' ovens. £	s.	d.
Durham and Northumberland:			
Blast Furnace Coke	1	8	0
Foundry Coke	1	10	6
Lancashire: Blast Furnace Coke	1	5	8
Midland Counties: Blast Furnace Coke	1	5	8
South Wales and Monmouthshire: Blast Furnace Coke	1	10	0
South Yorkshire: Blast Furnace Coke	1	5	8
West Yorkshire: Blast Furnace Coke	1	5	8
	Per ton net. f.o.t., Makers' works. £	s.	d.
Hematite Pig-Iron—East Coast.			
Mixed, Numbers 1, 2 and 3	6	2	6
Special quality, containing under 0.04 of Phosphorus and Sulphur	6	7	6
Special quality, containing under 0.03 of Phosphorus and Sulphur	6	15	6
Special quality, containing under 0.02 of Phosphorus and Sulphur	7	0	0
Hematite Pig-Iron—Scottish:			
Mixed, Numbers 1, 2 and 3	6	2	6
Special quality, containing under 0.03 of Phosphorus and Sulphur	6	15	6
Special quality, containing under 0.02 of Phosphorus and Sulphur	7	0	0
Hematite Pig-Iron—Welsh:			
Mixed, Numbers 1, 2 and 3	6	2	6
Special quality, containing under 0.03 of Phosphorus and Sulphur	6	15	6
Special quality, containing under 0.02 of Phosphorus and Sulphur	7	0	0
Hematite Pig-Iron—West Coast:			
Mixed, Numbers 1, 2 and 3	6	7	6
Special quality, containing under 0.03 of Phosphorus and Sulphur	6	15	6
Special quality, containing under 0.02 of Phosphorus and Sulphur	7	0	0
Cleveland Pig-Iron:			
Number 1	4	11	6
Other grades	4	7	6
Derbyshire, Leicestershire and Nottinghamshire Pig-Iron:			
Forge	4	5	0
Foundry Numbers	4	7	6
Lincolnshire Pig-Iron:			
Basic or Foundry	4	7	6
Northamptonshire Pig-Iron:			
Forge	4	2	6
Foundry Numbers	4	5	0
North Staffordshire Pig-Iron:			
Forge	4	10	0
Foundry	4	12	6
Basic	4	15	0
South Staffordshire, Shropshire and Worcestershire Pig-Iron:			
"Part Mine" Forge	4	10	0
"Part Mine" Foundry	4	12	6
Common Staffordshire	4	5	0
"All Mine" Forge	5	10	0
"All Mine" Foundry	5	15	0
"Warm Air" Forge	7	0	0
"Warm Air" Foundry	7	10	0
Special Quality Lord Dudley's Silicon	7	17	6
Cold Blast Iron	8	17	6
Scottish Foundry and Forge Pig-Iron:			
Nos. 3, 4 and lower grades of Monkland, Dalmellington, Eglinton and Govan	5	14	0
Nos. 3, 4 and lower grades of all other brands	5	15	6
No. 1 quality (Scottish) to be 5*s.* per ton above these prices.			

To the above-mentioned prices for pig-iron a sum not exceeding 1¼ per cent. on such prices may be added in the case of sales by persons other than the Makers.

Maximum Basis Prices for Steel.	£	s.	d.
Ship Plates, ¼-in. and over	11	10	0
Boiler Plates	12	10	0
Subject to extras for special thickness, sizes and qualities not exceeding those customary in district of manufacture.			
Angles, ordinary sizes	11	2	6
Joists, ordinary sizes	11	2	6
Rails (railway), over 60 lb. per yard	10	17	6
Sheet and tin plate bars	10	7	6
Blooms and billets, ordinary mild steel	10	7	6
Blooms and billets, special	11	0	0
Rounds and squares, 3 to 5½ in. diameter or square (untested)	12	10	0

Tees, channels, flats, bulb angles, zeds and other sections of which the prices are customarily based on the price of angles to be at price of angles, subject to extras not exceeding those published in any list recognised by the trade in the district of manufacture and current on July 7, 1916.

All subject to extras for special sizes and qualities not exceeding those published in any such list as above.

Heavy Steel Melting Scrap ... 5*l.* 10*s.* per ton delivered Buyers' Works.

Turnings and Borings ... 2*l.* 15*s.* per ton delivered Buyers' Works.

Maximum Price for Bar Iron.

Standard quality, ordinary sizes and merchants' lengths, 13*l.* 15*s.* per ton net, f.o.t. makers' works.

Marked Bars, 15*l.* per ton less 2½ per cent. f.o.t. makers' works.

Subject to extras for special sizes and qualities not exceeding those published in any such list as above.

To the above-mentioned prices for bar iron and steel a sum not exceeding 2½ per cent. on such prices may be added in the case of sales by persons other than the makers.

Maximum Prices for High-Speed Tool Steel.

Finished Bars, 14 per cent. Tungsten 2*s.* 10*d.* per lb. delivered buyers' works.

Finished Bars, 18 per cent. Tungsten 3*s.* 10*d.* per lb. delivered buyers' works.

(Subject to usual extras for special sizes.)

Scrap:

Millings and Turnings, 5*d.* per lb. net, delivered Steel Makers' Works.

Bar Ends, 6*d.* per lb. net, delivered Steel Makers' Works.

All communications with reference to the above order and permit should be made to the Director of Materials, Armament Buildings, Whitehall-place, London, S.W.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further particulars on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia.—The Melbourne Office of H.M. Trade Commissioner in Australia has forwarded copies of the specifications and forms of tender in connection with calls for tenders by the Victorian Government Railways, as follows:—Sealed tenders, on the proper forms, will be received up to 11 a.m. on September 6, by the Victorian Railway Commissioners, Spencer-street, Melbourne, for the supply and delivery of (1) 12 three-phase crane motors and controllers and 11 one-phase workshop motors and starters (Contract No. 30,110); and (2) 3 dry grinding machines, 2 beading and coping rolling machines, and 2 tube swaging machines for railway workshops (Contract No. 30,203). Tenders must be accompanied by a preliminary deposit of ½ per cent. of the amount of the offer in each case. Local representation is necessary.

Spain.—The *Gaceta de Madrid* publishes a Royal Decree authorising the Spanish Ministry of Finance to present to the Cortes the general State Estimates for 1917. The following are some of the chief items assigned in favour of the "Ministerio de Fomento" for public works:—*Roads.*—Upkeep of roads, 27,340,959 pesetas; new road works, 27,334,445 pesetas; repair of roads, 11,675,837 pesetas; street paving, &c., works in Madrid, 2,040,000 pesetas. *Railways.*—Surveys and general expenses, 1,245,000 pesetas; constructional work and subsidies to railway concessionaires, 12,375,000 pesetas. *Ports, irrigation, &c.*—Port works and services, 14,224,380 pesetas; lighthouses, 1,484,863 pesetas; new hydraulic works, 8,287,354 pesetas; the Aragon and Castille canals, &c., 6,132,646 pesetas. (25 pesetas = £1 (par rate).)

OUR COAL ABROAD.—The falling-off in our coal exports is becoming more considerable, the shipments in June having been 3,265,698 tons, as compared with 3,557,306 tons in June, 1915, and 5,734,220 tons in June, 1914. For the first six months of this year the aggregate exports were 19,075,461 tons, as compared with 22,332,590 tons, and 34,586,938 tons in the corresponding periods of 1915 and 1914, the totals being increased to 20,504,687 tons, 23,377,174 tons, and 36,148,907 tons by the addition of coke and patent fuel.

CATALOGUES.

Zincs for Leclanché Cells.—Every user of Leclanché cells must have noticed that a very considerable part of the zinc rod employed in these cells is always wasted. In individual cases this waste may seem to be negligible, but when one considers the enormous number of cells in use in this country alone it will be evident that, collectively, it is of considerable importance, especially with zinc at its present price. When an ordinary cylindrical rod is employed in a Leclanché cell the action of the electrolyte appears to be greatest somewhere about one third of the length from the lower end, and the rod eventually breaks off at this part, leaving the upper end but little affected. It is thus possible to reduce the diameter of the upper part of the rod without affecting the efficiency of the cell or the life of the zinc, and this has been done by British Insulated and Helsby Cables, Limited, of Prescot, Lancashire, who have recently sent us a leaflet relating to the matter. The zincs now made by this firm have their largest diameter at the part where the greatest action takes place—*i.e.*, at about one-third of the total length measured from the lower end. From this part the diameter decreases equally in both directions to about two-thirds of its maximum value, and the upper end of the rod is cylindrical, as usual, but of the smallest diameter. The maximum diameter does not exceed that usually employed for the whole length of the rod, so that a considerable saving in zinc is effected by reducing the diameter as explained above. The zincs are made in three sizes, for 3-pint, 2-pint, and 1-pint cells.

Large-Power Oil Engines.—We have received from Messrs. William Doxford and Sons, Limited, of Sunderland, a pamphlet giving some particulars of a new design of oil engine they have constructed for demonstration purposes, and also giving the results of a long continuous trial. The engine, which forms part of a four-cylinder vertical engine designed to develop 1800 brake horse-power at 130 revolutions per minute, has a single cylinder, 19.6 in. in diameter, in which two pistons work in opposite directions. The upper piston operates a crosshead placed above the cylinder, and the crosshead is connected to the crank-shaft by two side rods and two connecting rods; the lower piston is connected to the crank-shaft in the usual manner by a single piston rod and a connecting rod. Both pistons have a stroke of 29½ in. The engine works on the two-stroke, constant-pressure cycle, and the fuel oil is injected into the cylinder horizontally between the two pistons, which thus form the top and bottom surfaces of the combustion chamber. This is an important feature of the design, which obviates any local action of the fuel on the piston heads. Among other advantages claimed for the design it is mentioned that the main bearings are almost entirely relieved from pressure, since the loads on the two pistons practically balance each other; the cylinder is a plain tube of nearly uniform thickness; large powers can be obtained from cylinders of small diameter; and the small diameter greatly facilitates the cooling of the cylinder and pistons. Another important point is the absence of cylinder heads, which are usually intricate castings in which unknown stresses are produced by pressure and unequal heating, as well as in the course of manufacture. Various trials were carried out on the engine with a 50 per cent. overload, a 25 per cent. increase of working pressure, an increase of speed to 150 revolutions per minute, and an increase in the temperature of the cooling water to 200 deg. Fahr. from its normal value of from 160 to 170 deg. Fahr. The results obtained were quite satisfactory, and no detrimental effects of any kind were discovered, though the working parts were thus subjected to stresses far in excess of the normal. A trial was then carried out with the engine running, under the supervision of officials of Lloyd's Register, for 34½ days without a stop, and developing 470 brake horse-power at 112 revolutions per minute. A photograph reproduced in the pamphlet shows that at the end of the run the piston heads were clean and the rings quite free. The consumption of fuel oil was about 0.43 lb. per shaft horse-power hour, but the kind of oil used is not stated in the pamphlet. We understand that no difficulty is experienced in burning the heaviest fuel oils without using ignition oil, and that tar oils, Mexican crude oil, Californian oil, Roumanian residue, and Russian Mazut have been successfully employed. The engines are being standardised for stationary work as well as for marine propulsion.

LIQUID HYDROGEN, DENSITY AND REFRACTIVE INDEX.—The most recent determinations of the density and refractive index of hydrogen made by Dr. Herbert Augustin (*Annal. Physik*, volume 46, page 419) are in close agreement with the values found by Dewar and by Kamerlingh Onnes. To determine the density, Augustin, at Leipzig, suspended a cylindrical body of quartz, 23 cub. cm. in volume, by a fine platinum wire (attached to a balance) into the liquid hydrogen contained in a Dewar vessel. The density found was 0.07105 at — 252.83 deg. Cent, and 745.52 mm. pressure; Dewar had found 0.07 or a little more, Onnes 0.07093. The refractive index was determined by the total-reflection method of E. Wiedemann, the plane-parallel plate consisting (as in Dewar and Liveing) of two plates, 3 mm. in thickness, cemented together by a piece of tissue paper soaked in egg albumen, the paper having a hole in the centre. Five determinations were made, for wave-lengths between 6560 and 4040 Angström units, and the refractive index rose from 1.0924 to 1.11262 with decreasing wave-lengths. The refractive index of liquid nitrogen, determined for the same wave-lengths, rose from 1.19715 to 1.20125. From a consideration of A. Wiener's views on the connection between density and refractive index, Augustin suggests that the molecules of liquid hydrogen are of spherical shape.

PARAFFIN CARBURETTOR.

THE high price of petrol is directing the attention of owners of commercial vehicles to paraffin, which is, of course, very much cheaper. For a long time the owners of motor-boats have used paraffin with success, the greater power they require and the constant load having made economy more urgent in their case. Petrol has, however, held its position on land due to its great adaptability to varying loads and to the ease with which a motor can be started with it when all is cold. There is, however, no reason why petroleum should not be used if the necessary precautions are taken to adapt it for the purpose in view. Several carburettors have been brought out for this purpose, and yesterday there was a successful public demonstration at Burford Bridge, Surrey, of one which is manufactured by Messrs. S. Smith and Sons (Motor Accessories), Limited, of 179-185, Great Portland-street, London, W. The carburettor itself is of the usual Smith type, but to that is added the King paraffin attachment. The object of this is to feed the cylinders at starting with petrol vapour, and then, when they have become warmed, to add petroleum vapour from one or more auxiliary nozzles, according to the demand for power. If this demand is greater than the petrol jet and one paraffin jet will supply, the petrol jet is cut off as the second and third paraffin jets are brought into action, and by this arrangement, it is stated, the percentage of petrol used is never more than 20 per cent., against 80 per cent. of paraffin.

Figs. 1 and 2 explain the action, while Fig. 3 shows a slightly modified arrangement. There are two float chambers, A for paraffin and B for petrol. Connected to these are four jets, each fitting into a separate choke-tube or port. A valve, or dashpot at C, sliding on the central spindle, brings these successively into action according to the speed of the engine. Before the engine is started the controlling valve is at its lowest position and all the ports are shut, with the exception of the first, which remains half open. When the engine is turned the suction atomises the delivery from this jet, and starting is effected. As the throttle opens and the engine suction increases, the controlling valve rises and opens successively the second, third and fourth ports, all of which are supplied with paraffin. These three jets, as explained, have a separate float, distinct from that which controls the petrol jet. When the third jet—that is, the second paraffin jet—is opening, the valve cuts off the petrol jet completely.

It is well known that it is not sufficient to atomise paraffin, since liquid particles, or vesicles, are then carried into the cylinder and dissolve the oil on the wall. The paraffin must be actually vaporised, and to this end it is necessary to heat it. Around the float chamber A and the valve chamber C there is a water jacket, and through this the circulating water is continually passed by the pump from the pipe E to the pipe F, imparting a portion of its heat to the oil. Further, lest the evaporation should again reduce the oil to the precipitation point, the inlet pipe B to the cylinders is also jacketed, and a part of the exhaust gases is passed through the envelope, entering at the top and leaving at the bottom.

There is certainly no scientific reason why paraffin should not be used in motor vehicles, provided that it always enters the cylinders in the form of gas, and this end seems to have been successfully attained by the King paraffin attachment.

ENLARGING PHOTOGRAPHS WITHOUT A LENS.—A curious method of enlarging photographs by a simple mechanical process without the use of a lens is described by Mr. A. J. Lotka, of New York, in the *Physical Review* of June, 1916. The negative to be enlarged is moved past a narrow slit-source of light, and the sensitive plate underneath it is moved at the same time at n times the rate of the negative; the enlargement will then be n times. In the actual device a lamp hangs over the slit; underneath the slit is first the original negative, then close to it the sensitive plate, and the carrier in which the plate is resting. If the movement is horizontal with regard to the picture, the positive obtained by developing the sensitive plate will be magnified n times in the horizontal direction and not magnified in the vertical direction. The process is now repeated, the positive having been turned through 90 deg. in the carrier; then the enlargement will only affect what had been the vertical direction in the original picture, and the final picture will again be a negative on n times the original scale. When n is to be 2, the two-fold movement can simply be effected by means of strings passing from the carrier through eyes on both sides of the negative and to the box; the carrier is pulled by another string, and will travel at twice the rate of the original. Other magnifications can be secured with the aid of a simple device, which Mr. Lotka has patented. The novel method gives an enlarged copy free of distortion and of uniform illumination over the entire field. Two exposures are required to obtain an enlarged negative; that would be so with ordinary lens photography, of course, but the old process looks quicker, and distortion is hardly to be feared with modern lenses. With large magnification the realisation of a uniform movement would probably be more troublesome than the distortion due to lenses.

THE KING PARAFFIN CARBURETTOR.

CONSTRUCTED BY MESSRS. S. SMITH AND SONS (MOTOR ACCESSORIES), LIMITED, LONDON.

Fig. 1.

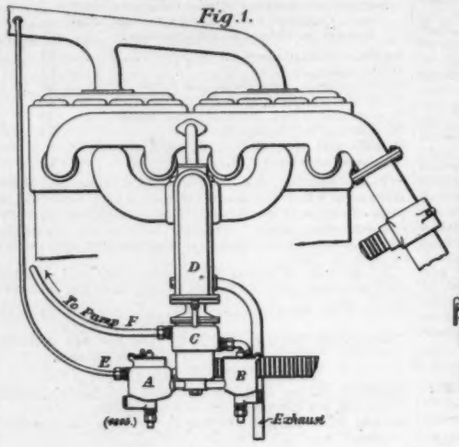

Fig. 2.

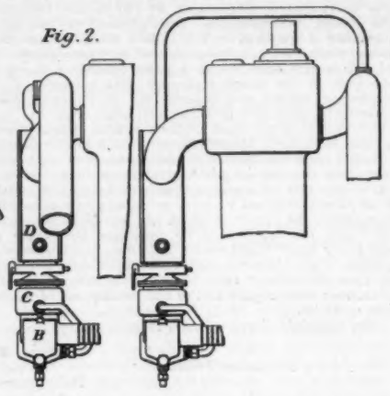

Fig. 3.

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—I am interested, as many others of your more humble readers are, in the correspondence now appearing under the heading of "Draughtsmen," and the remarkable letter in your issue of the 7th inst. has roused me from my lethargy. Surely the writer must be the person of "push and go" so extensively advertised for by the Government—the missing link, in fact. A wider experience and closer observation of the workings of the Regulations as they affects draughtsmen—the brains of engineering establishments—would have modified his production; perhaps, however, it is the judgment that comes with years that is required. The name and address, with hints as to the best means and time of day for "tackling" his employer would be appreciated by

Yours truly,

July 8, 1916. CLYDESIDE.

TO THE EDITOR OF ENGINEERING.

SIR,—The correspondence now being carried on in your valuable columns in connection with the status of an engineering draughtsman is of extreme importance to all who are engaged in this exacting profession, and as I am one who has already spent nearly 25 years in its various branches, I claim to have gained some knowledge of the unfortunate position into which the profession has been allowed, due to lack of combination, to descend. Matters have reached that stage when united action becomes important to prevent a further descent to the level of that reached by the clerk some few years ago, before anything like a combination was assured amongst the well-trained of the clerking profession. Until something is done by way of amalgamation to put a stop to the action of employers who expect the highest results both in skill and knowledge from the draughtsman employee, matters will not improve.

Perhaps the employers are, after all, not wholly to blame in their action, seeing the absolute weakness displayed by the profession generally, and knowing in most cases the prime cause of such weakness. I refer now to the introduction of a type of self-termed draughtsman who, having gained a rudimentary knowledge of the art of line drawing, has the colossal assurance to class himself with the genuine article, one with a life's training behind him coupled with a brain, and natural skill, which is conspicuous by its absence from him who imagines a few hours' training at a third-rate evening class is sufficient for the position desired. The employer takes advantage of the fact that hundreds of young men, having been released from colleges and training centres, offer their services for a salary which is just a bare expense return, and in the hope—vain usually—that out of many offers a few reasonable units might be found, the employer decides to engage from the ranks of the inefficient, cheap, and nasty. One may argue that the mistake is realised to the benefit of the genuine draughtsman, but the damage has already been done, for in his knowledge of the great and increasing weakness of the profession due to lack of combination and organisation, he has perforce to agree to the lower and still lowered terms of the employer; so in the end he—the employer—obtains a highly skilled man at a ridiculous salary.

It is time this state of affairs was rendered inoperative by the action of a combined element of skilled and qualified engineering draughtsmen who should by their combined action show the masters their mistake in imagining a highly trained thinker and creator—for it is often so—can be procured for a few shillings per week. Before the workman mechanic can start up his machine, before the machine even can be given work to do, before the work can be obtained, and almost before everything it is the draughtsman who is the responsible person; it is he who is under consultation in the early stages of a construction—its initiation, its subsequent development and completion; the trained draughtsman to-day is and must be an engineer; before he can hope to grapple with any problem properly he must have spent years in works, years in commercial life, years in the drawing and designing office; no automatic tool produces his work; everything, every action is brain-controlled in the strictest sense; even the early stages of his work combine all that is required of the mechanic at the present day machinery, and I say this in no way bitter toward the mechanic, but only to show that what organisation has done for one, it may and must do for another, and place the skilled draughtsman on his pedestal again so that he may rank with those of other professions both as regards salary and status, and ensure for him a prosperous future.

I enclose my card and trust you may be able to find space for these few remarks, not to end matters, but to open them up still more, so that many others may become interested in the welfare of an engineering draughtsman.

Yours truly,

X. Y.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to your correspondent, Mr. H. S. Ellson, I beg for space to make a few remarks. *Apropos* of his reply to "Staffed," it is surely evident that were one, at the present time, to give up a job due to a decrease in wages, it might be rather difficult under existing conditions to obtain another situation unless such decrease were conclusively proved to be unwarranted.

With reference to his "self-reliant and self-confident attitude," it might be suggested that this is not necessarily always in direct proportion to a man's engineering ability, and, further, that the individual with the broadest education is usually very sensitive to his own shortcomings and under no illusions as to his indispensability.

Apart from this, however, I think that your correspondent takes a rather narrow view of the scope of an Association of Engineering Draughtsmen. Such a body, had it existed, could at the present time have helped to increase materially the efficiency of the engineering industry. One cannot help being impressed with the futility of "situations vacant" columns, where the following advertisement is typical of many: "Wanted at munition factory as departmental managers, energetic young men of good education who have been discharged from the army or are ineligible. Must be capable of doing a good day's work. Engineering experience an asset." Here we have one of those factories on which the existence of our country and the lives of our soldiers depend reduced to stipulating for a man who can do "a good day's work" and which at the same time, while admitting that engineering experience is an asset, is not in a position to command this qualification.

Now as "No person on Government work need apply," and as all eligible men otherwise engaged have been called up, that leaves three classes: those over age, unfit, and discharged, as possible applicants for all existing vacancies. It is very improbable that all these can be filled, and that, most efficiently, from this source, as the choice even among these is limited to those not in controlled establishments.

An association, however, would have been in a position to submit for consideration the qualifications of any of its members fitted for these posts and, while exercising discretion as to claims for more efficient employment, could have put these forward in a systematic and businesslike manner. It would strike one, then, that if such an advantage could accrue during a time like the present, surely something similar would hold good during the period of severe commercial world-competition following the war.

Yours truly,

Glasgow, July 10, 1916. EFFICIENCY.

BOILER-HOUSE DESIGN AND OPERATION.*

By W. W. LACKIE, Engineer and Manager, Glasgow Corporation Electricity Department.

THE design, equipment and operation of a boiler-house in connection with an electricity generating station invite attention to a variety of quite distinct engineering problems, almost any one of which would require a paper to itself. In the time at our disposal attention will necessarily be confined to a general survey of the boiler-house as a whole, and it may be that passing reference to certain of the details of boiler-house design and equipment will lead to a fuller consideration and discussion of these.

Two years ago Mr. Fedden read a paper on this subject, but as coal and its economic use have been very forcibly brought before us during the past year, it was thought that a further paper and discussion on the subject might be to the advantage of all concerned. Many considerations have now to be kept in view in the design of a modern boiler-house, but the main object has come to be to have the maximum of steaming capacity in the minimum of space. The necessity for this has largely been brought about by the introduction of turbine-driven generators and the ever-increasing size of generating sets. Twenty years ago, in the design of a generating station, it was a simple matter to install an additional boiler for each addition to the engine-room plant, as a reciprocating engine of 500 horse-power, or even 1,000 horse-power, with its generator occupied practically the same amount of space as the boiler plant required to supply steam to such sets. In these early stations the area occupied by the boiler-house was practically the same as the area necessary for the engine-room, and extensions were easily made. On account of the poor load factor which prevailed in these stations, due to the fact that the demand was mainly for lighting supplies, the limited area of supply, and the central site chosen for the station, economisers were seldom installed and the stations were run non-condensing. The power per square foot in the engine-room varied, but 1 horse-power per square foot of engine-room floor space was an average figure. The boiler-house was, as a rule, a one-storey building, and an evaporation of 14 lb. of steam per square foot of boiler-house floor space, or 42 lb. per square foot of boiler floor space, was the steaming capacity. This was considered a good average figure. The boilers were hand-fired and the coal store was the floor in front of the boiler or a bunker in front of and practically on the same level as the boiler. All ashes had to be removed by hand on to the boiler-house floor or direct into hand-barrows, to be wheeled away at any convenient time.

A few years later, when it began to be recognised that the supply of electrical energy for power purposes was an economic possibility and larger stations were being erected, the power per square foot of engine-room space per horse-power was not seriously increased, as condensing engines were installed, and the space required for condensers increased the size of the engine-room and increased the total space occupied by the steam-using plant. Larger boilers were used, but economisers were then installed, and these were, as a rule, on the boiler-house floor level, and the evaporation per square foot of boiler-house space was not seriously increased.

The further growth in the demand for electric energy, the much improved load factor, and the introduction of the use of the steam turbine for the driving of electric generators about the year 1904, brought about a distinct change in the relative space required for engine-room plant and boiler-house plant. The turbine-room came to consist of a two-storey building, the condensers being on the ground floor or basement floor, and the turbo-generators on a floor above. Instead of having 1 horse-power per square foot of engine-room floor space, we have to-day turbine-rooms with 5 horse-power per square foot, and in designs for new power stations, using 15,000 to 30,000 kw. sets, this figure may go up to 20 horse-power per square foot of engine or turbine-room floor space.

With this enormous increase of power per square foot of turbine-room, changes in boiler-house design are absolutely imperative, particularly in the lay-out of the boilers, otherwise the space occupied by the boiler-house will be out of all proportion to the space allotted to the turbine-room.

It is now recognised that even with improvements in boiler-house design, where very large turbo-generators are in use, every pair of such sets requires a separate boiler-house. Several present-day power-houses have an evaporation of 50 lb. of water from and at 212 deg. F. per square foot of ground space occupied by the boilers, but it is possible with improved design of the boiler-house plant to approach an evaporation of 100 lb. from and at 212 deg. F. per square foot of the ground space actually occupied by the boilers. We therefore find that while the engine-room floor space and the boiler-house floor space were 20 years ago about equal, and remained so even for 10 years thereafter, to-day in a large modern generating station the ground space occupied by the boiler-house is from 1¼ to 2½ times the space occupied by the turbine-room.

The first consideration is to ensure the maximum grate area per square foot of boiler-house floor space, and it appears that burning coal with natural or induced draught at from 25 to 30 lb. per square foot of grate area there is a limit to the maximum possible continuous output per square foot of grate area, and that consequently there is a limit to the maximum power per square foot of boiler-house floor space. Arranging the boilers and economisers all on one floor practically doubles the area of the boiler-house; and in a modern boiler-house anything which adds to the area is to be avoided wherever possible. It is in fact now recognised that a modern boiler-house should consist of three storeys at least: the basement or ground floor containing ash-handling plant, the second floor containing the boilers proper, and the third or upper floor containing economisers and coal-conveying machinery and probably coal storage in the form of overhead hoppers above the boilers. Draught fans may be placed on any one of the three floors.

The question of chimneys and chimney draughts is by no means settled, but in stations where boilers of 50,000 lb. capacity are installed it is necessary to erect a separate chimney for each boiler or each pair of boilers. One is practically compelled to adopt steel in preference to brick for chimneys in a modern boiler-house, as with steel the chimney can be erected from the third floor, on which the economisers are placed, whereas if brick is used foundations have to be laid on the basement or ground floor and the structure continued to the third floors, at which point only it comes into useful commission. The brick chimney foundations and superstructure up to the second floor simply mean a waste of valuable space and a mass of brickwork which serves no useful purpose.

It is desirable not only to deal with ashes ejected from the boilers, but also to deal with riddlings and any semi-burned fuel. These riddlings have to be returned to the coal-conveying plant and thence to the overhead coal-hoppers, so as to be used again in the furnace.

The necessity for concentration of power has made the water-tube boiler indispensable for the modern power-house. The evaporative capacity of any boiler depends upon the grate area, or, in other words, the quantity of coal which can be burned underneath it, and consequently the maximum concentration of power is obtained when the whole of the generating and recuperating surface is assembled directly over the grate. Even with this type of plant the assembling of the heating surface over the grate area is undergoing modifications in order that the highest possible evaporation per square foot of ground space may be obtained.

The space actually occupied by boilers at present, with the necessary passages between, does not as a rule exceed 33 per cent. of the total boiler-house floor space, and of this 33 per cent. the grate area only accounts for one-half.

Let us consider the case of a boiler-house which has to supply steam to two 15,000-kw. sets. The steam required for each set will amount to between 180,000 and 200,000 lb. of superheated steam per hour. This steam under modern conditions would be supplied by four boilers, each capable of generating 50,000 lb. of steam. Each boiler will require to burn at least 7,000 lb. of coal per hour, depending upon the calorific value of the coal. This means that grates of 250 to 270 sq. ft. will be necessary. A grate area of 250 sq. ft. means that each boiler will actually occupy, with passages between, about 500 sq. ft., eight boilers will require 4,000 sq. ft., and the boiler-house will have a floor area of 12,000 sq. ft. Fig. 1 (page 48) shows a plan of such a boiler-house, Fig. 2 is a cross-section, and Fig. 3 a longitudinal section.

From what has been said it is clear that increasing the size of the boiler unit will not of itself seriously increase the power per square foot of floor space. Twenty years ago water-tube boilers of 4,000 to 6,000 sq. ft. heating surface were considered large. To-day boilers are made with a heating surface from 10,000 to 20,000 sq. ft. In Detroit five boilers each with over 20,000 sq. ft. heating surface are in use.

The plan of installing boilers (apart from economisers) on two floors ought only to be adopted where the exigencies of the site render such an arrangement inevitable; that is to say, where land is dear or where local building regulations limit the dimensions of buildings in certain areas. In the new station of the United Electric Light and Power Company at 201st-street, New York (notwithstanding that this district is a suburb of New York) the company have been forced to adopt the flatted arrangement for their boiler-house in order to comply with City requirements.

The boiler-house must no longer be a stokehold with an atmosphere of grime and dust and dirt. It should be designed to admit of an ample supply of natural daylight. This is managed by placing the boilers back to back instead of face to face, with a firing floor down each side instead of down the middle between the two rows of boilers. Light can then be had from windows in the side walls as well as from the roof. This, however, means a larger floor area and a space between parallel boiler-houses, and further increases the ground area occupied by the power-station. Such an arrangement is shown in plan on Fig. 4 and in section on Fig. 5. Adequate daylight can be got from roof lights with proper design of the roof, and Figs. 1, 2 and 3 show such an arrangement.

There is still a tendency to-day to construct the combustion chamber of boilers much too small. A combustion chamber should be of such dimensions as to allow ample space for complete combustion taking place and the products of combustion thoroughly mixing before coming on to the heating surface. The author finds that the older boilers had 2 to 2½ cub. ft. of combustion chamber per square foot of grate area. To-day similar boilers have 5 cub. ft. of combustion chamber per square foot of grate area. The Detroit boilers before referred to have 9 cub. ft. per square foot of grate area, and it is generally conceded that this fact is very largely responsible for the high efficiency of these boilers at widely varying loads.

It is not necessary to enter into the details of the usual fittings of boilers, such as safety valves, high and low water alarums, dial steam-pressure gauges and miscellaneous valves; but it may be said that the equipment of a modern boiler should include two draught-gauges. One of these should show the difference in pressure between the combustion chamber and the outlet from the boiler, *i.e.*, the difference in pressure across the boiler elements. This will be a measure of the flow of the gases through the boiler and will indicate when a boiler requires cleaning. The second draught-gauge should show the difference of pressure between the ash-pit and the outlet of the boiler. This second gauge will always read higher than the first, and the difference is obviously a measure of the draught through the fire. Steam-flow meters are as necessary on boilers as an ammeter is on a generator, as they indicate what each boiler is doing, and whether all the boilers are doing their fair proportion of the work. One or more CO_2 recorders have been for some years installed as part of boiler-house equipment, and these are found to be a valuable adjunct, as they are an index of the working efficiency of the boiler-house. A word of warning, however, is required against assuming that high CO_2 always means high efficiency. There may be a large quantity of CO present. There should be thermometers or pyrometers with dial face on every boiler, giving the temperature of the superheated steam leaving the boiler, also the temperature of the gases at the damper.

Steam Piping.—With boilers of the size under discussion, steam piping should be carried from each boiler or pair of boilers to a steam drum or receiver placed on the boiler-house floor or basement floor adjacent to the wall between the boiler-house and the turbine-room. This arrangement is preferable to one large steam header. From the steam receiver a steam pipe is led to a turbine and another pipe to the next receiver, so as to give interchange of steam from one set of boilers to another when required.

Appended are the results of an interesting series of tests on steam-pipe and boiler-drum covering materials to show their relative properties for the conservation of heat from high-pressure steam. The final temperature of the superheated steam in the power station varied from 550 deg. to 600 deg. F. Four firms were asked to cover three sample pipes 2 ft. long by 4 in. internal diameter, ¼ in. thick mild steel, with standard flanges on each end. The firms asked to quote were given a free hand as to choice of the material which would best meet the conditions. The thickness of covering was specified to be 2-in., the covering to be finished off at the flanges in a manner to suit flange-cover boxes of the usual dimensions. (Appendix I.)

We may at an early date see an increase in the boiler pressure from 160 and 200 lb. to 250 lb. The Commonwealth Edison Company of Chicago worked the boilers in their Fiske-street station at 200 lb. until 1907, when they adopted 225 lb. at their Quarry-street station, and in 1910 they adopted 250 lb. at their North-West station.

Fuel-Handling and Storage.—A station of 50,000 kw. capacity and burning 200,000 tons of coal per annum requires coal-handling facilities for a supply of 1,000 tons of coal per day, together with facilities for the handling of ashes to the extent of 100 tons per day. This means a railway siding capable of holding from 100 to 120 full trucks, and probably another siding of equal dimensions to hold the empty trucks. The provision of an adequate railway siding is therefore a costly adjunct in the lay-out of a large power house owing to the serious addition to the site which it entails. The length of railway sidings for a 50,000-kw. station would not be less than half a mile, or an addition to the site equivalent to 4,400 sq. yards. The wagons have to be tipped and coal-conveying plant has to be provided capable of handling 100 tons per hour. Coal-breaking machinery should be installed, for while we have in the past been in the habit of using small coal, circumstances may in the near future render it economical to buy and break larger coal. This question, however, brings in the whole question of mechanical stokers, and that subject would require a paper to itself.

Large coal storage accommodation is advisable and will prove economical. Not less than from two to four months' fuel supply should be retained. This marginal stock enables coal to be delivered in fairly regular quantities throughout the year and may result in lowering coal prices. The height or depth at which coal can be stored depends upon the class of coal, and the best method of storing coal is still undecided. The cost of lifting coal from canal barges or from trucks, and placing it overhead in coal hoppers or in the coal store, is a small item in the total price of coal. In one Glasgow station we have a coal transporter fitted with a 1-ton grab. This transporter cost 2,600*l.* and it handles coal at the rate of 40 tons per hour, and the cost of energy, labour and repairs on it brings the cost of handling coal in this way to just under 1*d.* per ton. In another station truck-loads of coal are elevated 30 ft. at one end of the coal store to an overhead platform, whence the coal is tipped into an overhead hopper or to the coal store, and the empty trucks lowered by a second elevator at the other end of the coal store. These two elevators, complete with electrically-operated capstans, cost 2,000*l.* The inclusive cost of handling coal in this way is 3½*d.* per ton, the higher cost being due to the amount of labour necessary for handling the trucks. These figures are conclusively in favour of the grab and transporter. Where coal has to be carried a short distance from coal store to boiler-house, bucket or tray conveyors appear to be the right thing. On the other hand, for longer distances, the telpherage system works out slightly cheaper, although the human element, with its attendant problems, enters more largely into the telpherage system.

For the removal of ashes, bucket conveyors have proved to be costly in upkeep on account of the wear of the axles and pulleys, caused by the fine, hard grit of ash dust; but even with this drawback, bucket or tray conveyors seem to be the cheapest method of removing ashes. Suction ash plant is finding much favour on account of the absence of moving parts in its design.

* Paper read before the Incorporated Municipal Electrical Association, June 22, 1916.

but the capital cost is very much greater (about three times) than that of bucket conveyors. Suction plants have not yet been long enough in use to warrant any definite pronouncement being made as to the repair bill. The cost for operating suction ash plant works out at about 5d. per ton handled, with energy at 1d. per B.O.T. unit. Suction plant is now made to do other work. It can be constructed for the purpose of elevating riddlings and small unburned fuel to a hopper or tank over the coal-conveying plant. It can also be made suitable for the removal of soot from economiser soot chambers and flue dust from the base of the chimneys. The efficiency of the ordinary vacuum cleaner is well known, and it appears that suction plant should be quite successful for the handling of this lighter material. The atmosphere in which all these operations are carried on is greatly improved by the action of the vacuum plant.

A modern boiler-house calls for comparatively large overhead ash storage, from which ashes can be dropped into wagons or other vehicles for their removal to a coup. The removal and disposal of ashes is becoming a serious matter. A few years ago ashes had a market value and we could get as much as 4d. or 5d. a ton for them. Then a time came when we were glad to get rid of them free of charge. To-day we have difficulty in getting the ashes from our stations carted away at 2s. a ton, paid to the carting contractor who undertakes their removal. It has been suggested that it would pay the large electrical undertakings to purchase 3-ton or 5-ton electrically propelled wagons for the removal of ashes, especially where convenient railway facilities are not available.

Coal-weighing machinery for each boiler or group of boilers is absolutely necessary if proper records are to be made of the boiler-house efficiency. It should always be possible to ascertain the amount of coal used in each 8-hour shift and at the end of each week or month, so that the coal used per kilowatt-hour generated may be ascertainable. These weighing machines should preferably be fixed between the overhead coal hopper and the boiler stoker, but some stations in America have a travelling gantry, fitted with a weighing machine at each end, the gantry travelling along the whole length of the boiler-house between two rows of boilers. The duty of the operator on this gantry is to move up and down the boiler-house and to weigh out regularly to each boiler a predetermined amount of fuel.

Feed pumps may either be of the direct-acting type or centrifugal, although experience with the former is so good and repairs so low that it will be difficult to displace them. The total condensate from the turbine-room condensers should be measured by a Lea or other water recorder, and this should have an integrating attachment.

Having ascertained the amount of coal used and having measured the condensate, we can get the amount of water evaporated per lb. of coal used. No very great increase in the efficiency of steam boilers can be looked for. The heat balance of many of the steam plants in operation at the present day is as follows:—

Heat absorbed by boilers	...	78 per cent.
Heat lost in flue gases ...	...	15.5 „
Heat lost in radiation and unaccounted for ...	...	6.5 „

That is to say, the total loss on which any reduction can take place is 22 per cent., but it is only a small proportion of this figure which can be attacked with a view to lowering it. It would be doing negative work to discharge the gases from a boiler at a temperature lower than that of the water in the boiler.

An evaporation of 4 lb. of water per square foot of heating surface in the boiler was, until recently, considered standard practice, but to-day water-tube boilers are designed, in conjunction with special economisers, to evaporate at the rate of 6 lb. normal load, and at overload 8 lb. and even 10 lb. per square foot of heating surface of the boiler. The heating area in most water-tube land boilers is of the order of 50 times that of the grate area. With such proportions the general practice is to emit the gases from the boilers at a temperature 500 to 550 deg. F., *i.e.*, from 100 to 150 deg. F. above the temperature of the steam at the boiler working pressure. The proportion of heating surface in economiser to heating surface in boiler varies in nearly every station, but the figure of 35 per cent. may be taken as a fair average. With such a proportion, allowing for heat drop in flues, the gases at the outlet to the chimney will have a temperature of from 325 to 350 deg. F., and the economiser will have utilised about 7 per cent. of the heat of the gases emitted from the boiler. The inlet water to the economiser from the hot-well will, with present-day practice, be raised to a temperature of 200 or 220 deg. F. Until recently the evaporation per square foot of heating surface of boiler and economiser combined was therefore roughly 3 lb. per square foot of heating surface. Modern practice tends to diminish the heating surface in the boiler from 50 times the grate area to 35 times the grate area and to increase the area of the economiser to 80 per cent. of that of the boiler heating surface. The result is to put up the evaporation of the boiler at overloads to 8 lb. per square foot of heating surface, and the temperature of the gases now emitted from the boiler is considerably raised, being about 650 deg. F. The heat, however, is taken up in the economiser and the temperature of the feed water to the boiler is considerably increased. The net result is that we get an evaporation of 4½ lb. per square foot of heating surface of boiler and economiser combined. The overhead economiser is suitably proportioned to give the very highest combined efficiency. Boiler plants arranged in this way probably give a higher efficiency than was the case with previous designs, inasmuch as the radiation losses are less and the loss between the boiler and the economiser is reduced to an absolute minimum. The modern tendency is, therefore, to supply feed water to boilers at a temperature as near as possible to the temperature of the water already in the boiler, and the boiler simply adds latent heat and superheat to the steam. Each boiler has its own economiser and the economiser is really an integral part of the boiler unit.

Two tests on boilers are annexed (page 50). The first was made on a land type water-tube boiler supplied eight years ago. The second was carried out on a modern boiler, designed as above indicated, and the results of the test bear out the contentions with regard to evaporation per square foot of heating surface and of floor space occupied. (Appendices III. and IV.)

Fuel.—An electric power station is simply a factory for the conversion of the chemical energy in coal into electrical energy. Coal is therefore the raw material of the factory; and as the final product, alike as regards reliability and price, depends first and last upon the quality and the regularity of the supply of coal, the selection and purchase of fuel are matters of the most vital importance.

The selection and purchase of fuel is a question naturally dependent upon the geographical position of the site relative to the nearest coalfields, and upon the nature of the load. An excellent discussion on this subject took place at one of our conventions a few years ago, and it is a matter for regret that there is no record or even a summary of that discussion, ably led as it was by Mr. Shawfield, then Engineer to the Wolverhampton Corporation Electricity Department. Power stations near the coalfields can use low-grade fuel with resultant saving in the coal bill, whereas it is often more economical to use high-grade fuel in stations remote from the coalfields, as the same freight has to be paid for ash as for carbon.

The kind of fuel also depends upon the nature of the load, as it is a recognised fact that a higher overload duty can be obtained from a boiler fired with good-quality coal with a given draught than can be got with low-grade fuel. If a station has a purely lighting load, and consequently a low load factor, a larger number of reserve boilers with their resultant radiation losses, &c., have to be kept under steam to meet any sudden peak loads than would be the case in a power station where the load is chiefly for power purposes, and consequently the load factor is high. In the former case it is often more economical to use the best coal, because, with the higher overload thus made possible, the number of spare boilers can be kept down to a minimum.

It is now almost universal practice to buy fuel on a calorific basis, but it must always be remembered that along with calorific value and analysis there are to be taken into account physical properties. For instance, two samples of coal may show an approximately similar calorific value figure and present wide differences of behaviour in the furnace. Actual boiler tests must therefore be made with sample truck-loads of coal if the best and most economical selection is to be made. Anthracite coal with very high calorific value will only burn economically at the rate of 8 to 10 lb. per square foot. I would certainly not advocate a slavish adoption of the calorific value basis in the purchase of coal, for the simple reason that coal is not a manufactured article, but a natural product, and if we are to hold the colliery

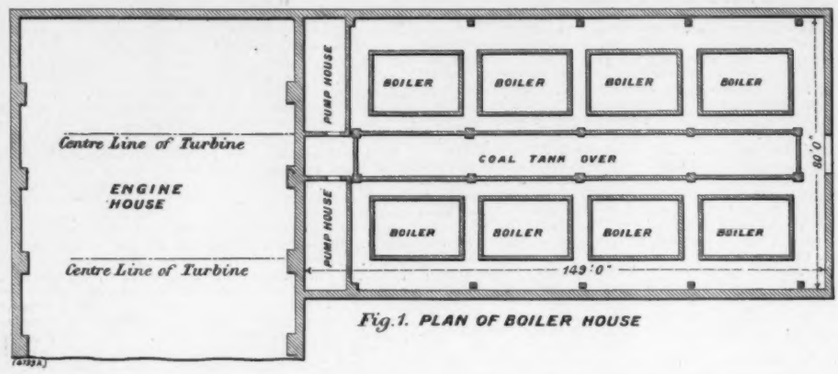

Fig. 1. PLAN OF BOILER HOUSE

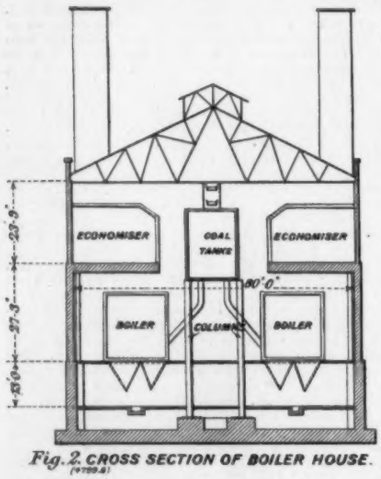

Fig. 2. CROSS SECTION OF BOILER HOUSE.

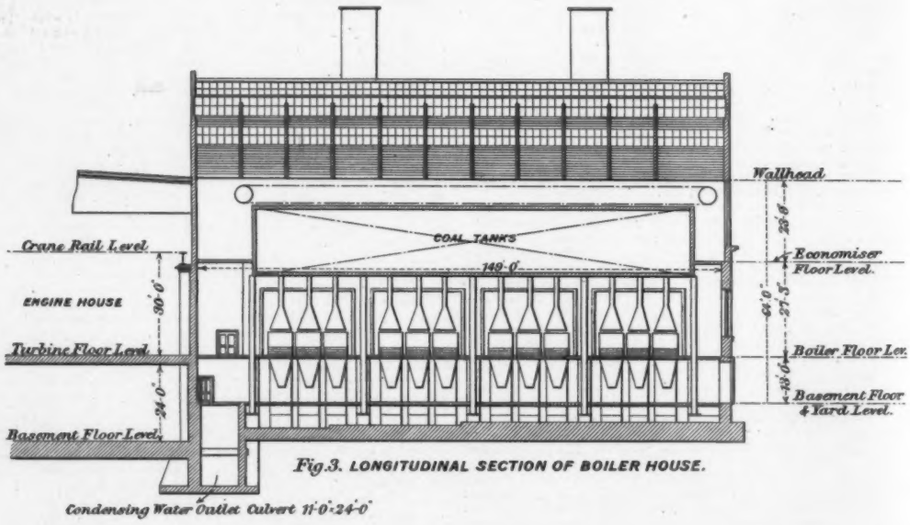

Fig. 3. LONGITUDINAL SECTION OF BOILER HOUSE.

Condensing Water Outlet Culvert 11'0"×24'0"

owner or his agent responsible for its calorific value, he will undoubtedly, and quite properly, cover himself by increasing the price accordingly; whereas if the coal contractor is not tied down, the customer is sharing the risk inseparable from a natural product. The contractor can be and should be generally tied down to supply from particular pits. In the Glasgow Corporation Electricity Department the calorific value of the different kinds of coal offered is judged by the previous year's experience, and if any particular kind of coal as delivered is below our previous year's experience of it, then that coal has a decreased figure of value allotted to it against the time when next it will be again offered.

A practical test in a boiler specially equipped for the purpose is a very reliable guide to calorific value. The results of such tests should be reduced to a common basis. A good unit of comparison is the cost of evaporation of 1,000 lb. of water from and at 212 deg. F., or the number of lb. of water evaporated for a pennyworth of coal, including coal and ash handling, which varies with the quality of the coal. It is usual to express the coal economic result for the whole station in lb. of coal per kilowatt-hour generated at the switchboard; but as this must obviously vary with the calorific value of the coal and the steam consumption of the engine or turbine plant, the better unit to use for general comparison is the British thermal unit per watt-hour, *i.e.*,

$$\frac{\text{lbs. of coal per unit} \times \text{B.Th.U. in coal as fired}}{1{,}000}$$

Even this is not perfect, as it does not allow for the variation in load factor between different power stations, but it does enable comparisons to be made irrespective of variations in calorific value. In two of the Victoria Falls power stations the economic result obtained in the way proposed gave in one station 27 B.Th.U. per watt-hour and in another 26. Both of these stations had very high load factors, whereas in many of the London stations, where the lighting load is predominant, the average result is in the neighbourhood of 40 B.Th.U. per watt-hour. Daily samples of coal, as delivered, should be sent to the laboratory of the undertaking for calorific analysis. An assistant, working with a bomb calorimeter, can test 12 samples a day working from 9 to 1 and from 2 to 5 o'clock. These tests are recorded in a coal test-book for reference. As the results of tests obtained by any or all of the methods above referred to are tabulated and arranged, an index of the pits in the coal-field, from which the fuel supply is mainly or wholly drawn, can be compiled, and coal prices as received can be equated on a calorific value basis.

An interesting experiment has been carried out in one of the Glasgow gas works recently. Gas-coke breeze or gas-coke riddlings were burned successfully on chain-grate stokers with forced draught. A special form of arch had to be built. This breeze can be bought at 20 per cent. the price of coal and it has a calorific value of at least 60 per cent. of coal. There is a large amount of ash, but the experiment went to show that with intelligent superintendence good results could be obtained with this class of fuel, although the actual output of the boiler was considerably reduced.

With regard to the whole question of fuel, experience seems to show that it is preferable to buy the best, for while good results may be obtained with inferior fuel, careful and constant attention to the fires is necessary with such fuel, whereas with first-quality fuel very little attention is required.

Boiler-House Staff.—Twenty years ago a fireman in a generating station was truly a fireman. Stripped to the waist, he had in many cases to lift every lb. of coal from the floor level to the furnace door. He had to be continually opening and shutting furnace doors and stirring up the fire. At regular intervals he had to bear excessive heat and noxious fumes, removing ashes from the furnace, which had thereafter to be wheeled away or shovelled direct into carts. It was no uncommon thing in such a boiler-house to have the fireman boasting that he had tackled the load with three boilers, whereas he might have saved both labour and fuel by having four boilers going.

All this has been or will soon be changed. The firing of the boiler is now done by operating a rope or a lever. A fire has rarely to be stirred or nursed in any way except by the adjustment of dampers and rate of feed. The substitution of mechanical and electrical machinery for hand labour naturally led to the substitution of the boiler-house engineer for the aforetime fireman. A competent boiler-house engineer is an indispensable adjunct to the boiler-house staff, and the man who knows his business can easily earn the substantial salary which he can command in this capacity. He, of course, trains his own labourers, but the human element should be, and is being, cut down as far as possible.

Everything possible should be done to obviate wastage of the heat value of coal in the boiler-house before the steam reaches the turbine. Many opportunities for waste, and consequently opportunities for devising ways and means to avoid waste, are still present in the boiler-house. In the present paper the possibilities of further improvement have been indicated as regards space, material, heat, labour, and time; and the sum total of the saving which would accrue even from the partial elimination of present waste under these various heads would represent a considerable proportion of the total charges on revenue in a large electricity supply undertaking. A saving of 1 per cent. in the coal bill of the Glasgow Corporation Electricity Department would this year represent a sum of 2,000*l.*

It is only in recent years that we have come to realise the meaning and the value of a lb. better steam consumption in a steam turbine. We now put a money value on steam consumption per $\frac{1}{10}$th of a lb. and stipulate for heavy penalties in the event of failure to comply with guaranteed consumption after allowing a tolerance of 2½ per cent. With an equipment such as has just been described, weekly returns can be prepared giving all the particulars any manager wants to satisfy himself that the plant is being properly handled and is doing its work efficiently. Turbine-room data being also available, a weekly sheet showing running statistics may be easily made out. A specimen sheet of this kind is annexed (Appendix II.). An exchange of such data between undertakings of about the same size would be mutually beneficial.

Recently in the *New York Electrical World* (April 8, 1916), a short but exceedingly interesting description was given of methods of handling boilers in a 100,000-kw. station. This referred to the boiler plant in the "L" station of the Edison Electric Illuminating Company at South Boston. The editorial referring to the article says: "It is evident in this central station that the electrical end of the establishment has no monopoly of scientific management," and continues that "the liberal use of recording instruments in the steam end of the station and the continuous expert study of operations . . . are all-important factors." The engineer in charge of the boiler-house is expected to maintain the highest efficiency possible with an economical expenditure of time and labour. In this station, containing 45 boilers, they have 36 steam-flow meters, 40 draught-gauges, 2 furnace indicators, 1 CO_2 recorder, 2 coal scales and 1 load indicator. In American stations generally considerably more attention is now being given to boiler-house economy, no doubt due to the increasing price of fuel. The workmen in the boiler-house are educated to interpret the various gauges and recording instruments and encouraged to take an interest in improving conditions. The instruments are not to be erected and stored away in the chief engineer's room, but are to be in the boiler-room.

Several very fine records of efficiencies have been attained in America. At the Conner Creek plant of the Detroit Edison Company, which has been in operation for a year, they have two 20,000-kw. turbo-alternators, and each turbine is supplied with steam by two large boilers, each boiler containing 23,500 sq. ft. heating surface. The plant is operating at the present time and producing a kilowatt-hour on 1.42 lb. of coal, *i.e.*, a little less than 20,000 B.Th.U. per kw.-hour. This shows an efficiency from coal to electrical energy of 17 per cent. The Chicago Commonwealth Edison Company in their Fiske-street station have two turbo-alternators of 20,000 to 25,000 kw. capacity. Over a whole year's run the coal used per unit of output was 1.92 lb., and the average value of the coal as fired was 10,120 B.Th.U. per lb. This gives an average of heating units in the coal as fired per unit of output of 19,450, and also shows a thermal efficiency of some 17 per cent.

The whole subject of fuel economy and the utilisation of coal has been very ably dealt with by Professor Bone in a series of three lectures delivered by him in January and February of this year. The British Association have also formed a Committee to look into the question of Fuel Economy, the said Committee being divided up into sub-committees, one of which is called the Power and Steam-Raising Sub-Committee.

If the result of this rapid survey of a number of points in connection with boiler-house design and equipment is a fruitful discussion, the purpose of the paper will have been served.

APPENDIX I.

TEST ON STEAM-PIPE COVERING.

Elements heated electrically were mounted on insulators and placed inside the pipes, the current to the elements being passed through terminals supported by bushes in the blank flanges. A thermometer pocket was inserted in the middle of each pipe, the test being to get a comparison of the amount of electrical energy taken by each pipe when the inside temperature of the pipe was kept constant. Care was taken to prevent draughts, the test being taken in a room 10 ft. by 8 ft. by 10 ft. high. Three sets of readings were obtained: one with the temperature inside the pipe at approximately 500 deg. F., the second at 550 deg. F., and the third at 600 deg. F.

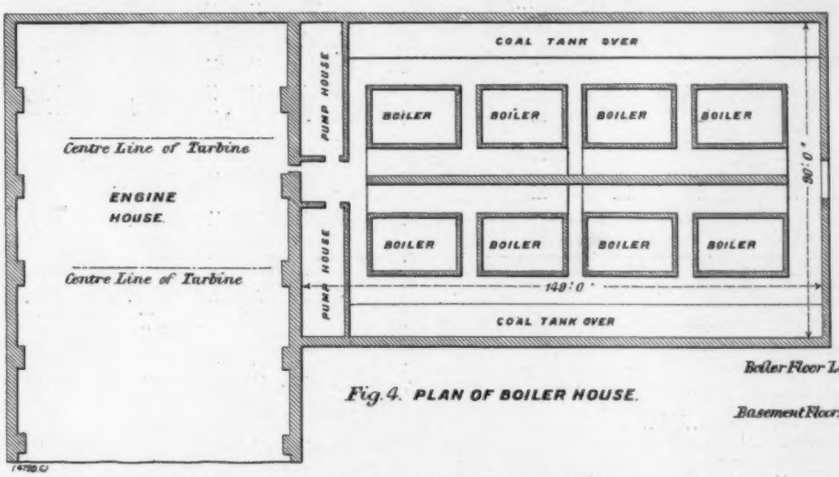

Fig. 4. PLAN OF BOILER HOUSE.

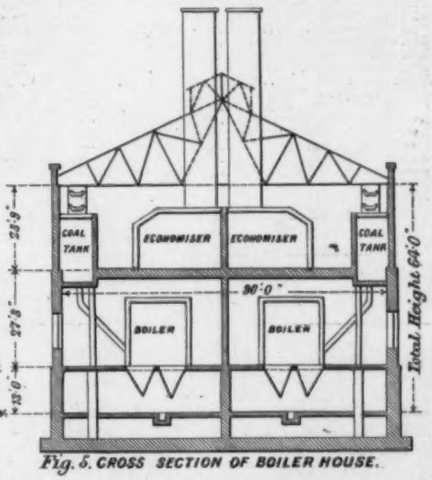

Fig. 5. CROSS SECTION OF BOILER HOUSE.

Report on Pipe-Covering Tests.

Pipe.	Temperature Steady. Deg. Fahr.	Temperature Rise. Deg. Fahr.	Watts Metre² × F°.
	FIRM I.		
A.	660	568	3.22
	598	512	3.42
	548	468	3.62
B	670	578	3.18
	610	524	3.38
	558	475	3.55
C	650	564	3.03
	598	515	3.18
	552	464	3.04
	FIRM II.		
A.	670	573	3.24
	608	514	3.56
	556	468	3.66
B.	665	568	3.32
	590	500	3.69
	541	451	3.80
C.	675	588	3.36
	589	495	3.62
	537	447	3.75
	FIRM III.		
A.	646	555	3.43
	598	508	3.54
	573	486	3.67
B.	661	570	3.34
	618	527	3.53
	551	464	3.75
C.	658	568	3.07
	585	494	3.24
	553	466	3.41
	FIRM IV.		
A.*	317	224	8.05
	302	212	7.95
	280	191	8.14
B.	640	580	2.79
	595	504	2.83
	578	489	2.90
C.	652	559	3.09
	608	518	3.10
	545	456	3.24

* Pipe unlagged.

The preceding table give the results of the tests, the last column in each case being the measure of efficiency of the pipe covering expressed in watts dissipated per square metre of pipe surface per degree difference. It is undesirable to give a description of the various coverings. Suffice it to say that they include all the best-known types and that the test of "A" covering, supplied by Firm IV., proved it to be the best; the final thickness of the covering in all cases being 2 in. full.

Evaporation per lb. coal as fired	7.56 lb.	7.75 lb.
Evaporation per lb. from and at 212° F.	8.53 „	8.90 „
Evaporation per lb. dry coal actual	8.26 „	8.92 „
Evaporation per lb. from and at 212° F.	9.32 „	10.24 „
Factors of evaporation, including superheater	1.128 „	1.148 „
*Evaporation per sq. ft. of ground space from and at 212° F.	78 „	105 „

APPENDIX II.

COPY

PORT DUNDAS STATION RUNNING STATISTICS.

(*For week ended May* 26, 1915.)

Items.	This Year.	Per Cent.	Last Year.	Per Cent.	Totals to Date from June 1, 1914. This Year	Per Cent.	Last Year.	Per Cent.
A.-C. units generated	1,170,745	—	979,735	—	61,210,255	—	50,329,462	—
D.-C. units generated	546	0.04	25,255	2.5	1,562,017	2.5	1,518,396	2 9
Total units generated	1,171,291	—	1,004,990	—	62,772,272	—	51,847,858	—
Units used in works	29,179	2.5	29,682	2.9	1,693,579	2.7	1,710,983	3.3
Units delivered	1,142,112	—	975,308	—	61,078,693	—	51,136,875	—
Maximum A.-C. load	15,000	—	11,400	—	19,400	—	16,100	—
Maximum D.-C. load	364	—	1,312	—	2,940	—	3,097	—
Combined maximum load	15,000	—	11,400	—	21,762	—	18,147	—
A.-C. load factor	46.45	—	51.1	—	36.11	—	35.7	—
D.-C. load factor	0.82	—	11.4	—	6.09	—	5.6	—
Combined load factor	46.47	—	52.4	—	33.01	—	32.6	—
Plant load factor (engine room)	77.92	—	68.6	—	77.55	—	77.0	—
Plant load factor (boiler house)	65.22	—	—	—	66.71	—	—	—
Coal burnt—tons	1,636.29	—	1,474.68	—	86,405.44	—	78,898.42	—
Lbs. coal per unit generated	3.13	—	3.28	—	3.08	—	3 41	—
Lbs. coal per unit delivered	3.20	—	3,38	—	3.16	—	3,52	—
Average cost of coal per ton	10/3.89	—	11/8.685	—	10/4.84	—	11/9.58	—
Total cost of coal	844*l.* 10*s.* 11*d.*	—	864*l.* 7*s.* 3*d.*	—	44,947*l.* 6*s.* 10*d.*	—	46,544*l.* 13*s.* 4*d.*	—
Cost of coal per unit generated	0.1730	—	0.2064	—	0.1718	—	0.2154	—
Cost of coal per unit delivered	0.1774	—	0.2127	—	0.1766	—	0.2228	—
Average calorific value of coal	11,500	—	11,250	—	—	—	—	—
Average flue temperature base of stack	200	—	311	—	506	—	343	—
Average CO_2	12.0	—	—	—	10.0	—	—	—
Ashes—tons	248.6	15.2	207.05	14.0	12,170.4	14.1	10,191.19	12.9
Turbine vacuum	26.1	—	26.5	—	—	—	—	—
Barometer	30.03	—	30.00	—	—	—	—	—

SUMMARY OF WATER METERS AND RECORDERS.

Make-up Water, Cooling, and all other purposes. Lbs.	Combined Water. Fed to Boilers. Lbs.	Lbs. Water per lb. Coal.	Lbs. Water per Unit.
11,270,000	24,751,250	6.75	21.15

APPENDIX III.

GLASGOW CORPORATION GENERATING STATION (PORT DUNDAS)

Test carried out on B. & W. Boiler fitted with Superheater and Chain-Grate Stokers. February 26, 1914.

Boiler supplied in 1906. Coal used—Scotch Peas.

Summary of Tests.

	1.	2.
General.		
Date of test	Feb. 26, 1914.	Feb. 27, 1914.
Duration of test	6 hours.	2 hrs. overload.
Heating surface of boiler	6,182 sq. ft.	6, 182 sq. ft.
„ „ superheater	1,088 sq. ft.	1,088 sq. ft.
Grate area	100 sq. ft.	100 sq. ft.
Ratio Boiler H/S to grate area	61.82/1	61.82/1
Draught used	Induced.	Induced.
Type of stoker	1 style 5 and 1 style 4.	Both grates style 4.
Ground space occupied	350 sq. ft.	
Fuel.		
Kind used	Scotch peas.	Scotch peas.
Calorific value as delivered	10,819 B.T.U.	11,330 B.T.U.
Percentage of moisture	8.35	13.08
„ „ volatile matter	32.23	37.35
„ „ fixed carbon	51.56	56.72
„ „ ash (analysis)	16.21	5.93
Total coal fired (wet)	19,300 lbs.	8,300 lbs.
„ „ (dry)	17,688 „	7,214 „
Average consumption of coal per hour (wet)	3,217 „	4,150 „
Average consumption of coal per hour (dry)	2,948 „	3,607 „
Average consumption of coal per sq. ft. of grate area per hour (wet)	32.17 „	41.50 „
Average consumption of coal per sq. ft. of grate area per hour (dry)	29.48 „	36.07 „
Combustible consumed per sq. ft. of grate area per hour	24.70 „	33.93 „
Total clinker	3,513 „	—
Percentage of ash to coal burned	18.20	—
Combustible	14,821 lbs.	6,786 lbs.
Steam.		
Quality	Superheated.	—
Average gauge pressure (lbs. per sq. in.)	188 lbs.	198 lbs.
Average temperature of saturated steam	383° F.	387° F.
Average temperature of superheated steam	561° F.	620° F.
Degree of superheat	178° F.	233° F.
Water.		
Total water evaporated	146,076 lbs.	64,334 lbs.
Evaporation per hour (tanks)	24,346 „	32,167 „
Evaporation per hour from and at 212° F.	27,462 „	36,028 „
Evaporation per sq. ft. H/S per hour actual	3.94 „	5.20 „
Evaporation per sq. ft. from and at 212° F.	4.44 „	5.97 „
Water Temperature.		
Average temperature of feed water entering boiler	248° F.	263° F.
Flue Gas Temperatures.		
Average temperature at boiler damper	508° F.	551° F.
Average temperature at economiser outlet	391° F.	395° F.
Draught.		
Average draught at boiler damper	15.0 mm.	23.0 mm.
Average draught at base of chimney	33.7 mm.	36.9 mm.
Flue Gas Analysis.		
Average percentage of CO_2	11.8	10.9
„ „ „ O	7.3	—
„ „ „ CO	Nil.	—
Furnace.		
Average thickness of left-hand fire	5½ in.	5 in.
Average thickness of right-hand fire	4½ in.	4 in.
Speed of left-hand grate	2 and 3.	2, 3 and 4.
„ right-hand grate	1, 2 and 3.	3 and 4.
Average ft. per hour: Left-hand grate	17.3 ft.	21.4 ft.
Right-hand grate	14.3 ft.	22.8 ft.
Temperature of boiler-house near grate	71° F.	71° F.
Efficiency.		
Combined efficiency of boiler and superheater	76.23%	75.87%
Heat Balance.		
Heat absorbed by boiler and superheater	76.23%	75.87%
Heat carried away in gases leaving boiler	12.96%	15.41%
Loss due to radiation and unaccounted for	10.81%	8.72%
	100.00	100.000

APPENDIX IV.

TESTS ON A MODERN BOILER FITTED WITH OVERHEAD ECONOMISER.

(Supplied 1915.)

Boiler.	
1. Type	Water tube.
2. Heating surface	4,061 sq. ft.
Superheater.	
3. Type	Integral.
4. Heating surface	1,460 sq. ft.
Economiser.	
5. Type	Steel tube.
6. Heating surface	3,080 sq. ft.
Stokers.	
7. Type	Chain grate.
8. Grate area	144 sq. ft.
Draught Plant.	
9. Type	Cold Air Ejector.
10. Height of chimney from firing level	77 ft.
Ratios.	
11. Boiler heating surface to grate area	28.3/1
12. Boiler and economiser heating surface to grate area	50.2/1
13. Economiser heating surface to boiler heating surface	77.3%
Complete Unit.	
14. Total heating surface (boiler, superheater, and economiser)	8,621 sq. ft
15. Total ground space occupied	383 sq. ft.

General.				
16. Date of test			Jan. 7, 1916.	Jan. 7, 1916.
17. Duty			Normal load.	Overload.
18. Duration			5 hrs. 8½ mins.	1 hr. 30 mins.
Fuel.				
19. Kind used			Washed nuts.	
20. Analysis: Volatile matter			28.75%	
Fixed carbon			67.25%	
Absolute ash			4.00%	
			100.00%	
Moisture			4.61%	
21. Gross calorific value of dried fuel			14,209 B.T.U	
22. Gross calorific value of dried fuel as delivered			13,554 B.T.U.	
23. Net calorific value of fuel as delivered			13,045 B.T.U.	
24. Total quantity fired			18,401 lbs.	5,687 lbs.
25. Coal consumed per hour			3,080 „	3,791 „
26. Coal consumed per sq. ft. of grate per hour			21.4 „	26.3 „
Steam.				
27. Average gauge pressure			165 „	166 „
28. Saturated steam temperature			372° F.	372° F.
29. Superheated steam temperature			673° F.	689° F
30. Degree of superheat			301° F.	317° F.
Water.				
31. Temperature entering economiser			93° F.	93° F.
32. Temperature leaving economiser			183° F.	180° F.
33. Total quantity evaporated			162,624 lb.	49,610 lb.
34. Evaporation per hour actual			27,218 „	33,073 „
35. Equivalent evaporation per hour from and at 212° F.			36,608 „	44,781 „
36. Evaporation per lb. coal, actual			8.84 „	8.72 „
37. Evaporation per lb. coal from and at 212° F.			11 89 „	11.81 „
38. Evaporation per sq. ft. of boiler heating surface, actual			6.67 „	8.10 „
38A. Evaporation per sq. ft. of ground space from and at 212° F.			95 6 „	116.9 „
Factors of Evaporation.				
39. Boiler and superheater			1.252	1.265
40. Boiler, superheater and economiser			1.345	1.354
Draught.				
41. Kind			Ejector.	Ejector.
42. Suction at economiser outlet			0.55 in.	0.8 in.
43. Power taken to produce draught			7.6 kw = 9.2 B.H.P.	13.8 kw. = 16.6 B.H.P.
44. Equivalent in steam consumption per hour (assuming 15.4 lbs. per kw.)			117 lbs.	213 lbs.
45. Percentage of steam generated			0.43	0.64
Flue Gases.				
46. Temperature entering economiser			577° F.	624° F.
47. Temperature leaving economiser			386° F.	419° F.
48. Average CO_2			12.4%	12.9%
Heat Balance.				
49. Efficiency of boiler, superheater, and economiser (based on gross calorific value of fuel)			85.00%	84.49%
50. Heat carried away in flue gases			9.20%	9.72%
51. Heat lost in radiation and unaccounted for			5.71%	5.79%
			100.00	100,00
52. Over-all efficiency, based on net calorific value			88.41%	87.79%

* If space occupied by economiser is added, these figures are reduced to 40 and 53 lbs. per square foot of ground space.

VANCOUVER.—Included in plans for the improvement of Vancouver Harbour is a terminal railway which will afford connection between existing lines, such as the Canadian Pacific Railway and the American Great Northern Railway and the reserve at Kitsilano, which lies at the mouth of False Creek. The Dominion Government has for some time been reclaiming land at False Creek at the Granville-street bridge, which is just east of the reserve. A large portion in mid-stream, which was exposed at low tide, has had a bulkhead put round it, and with the improvement of the channel large quantities of sand have been pumped behind. This will give a large area for sites for industrial purposes. An elevator on Burrard Inlet will have a capacity of 1,250,000 bushels; it lies at the land end of large new docks, and 3,000,000 dols. have been expended upon it and adjacent wharves.